London Borough of Hammersmith and Fulham

Updated Surface Water Management Plan

July 2015

UNITED KINGDOM & IRELAND

CAPITA | URS

Prepared for:

h&f hammersmith & fulham

47065080

REVISION SCHEDULE					
Rev	**Date**	**Details**	**Prepared by**	**Reviewed by**	**Approved by**
1	December 2013	Draft for client comment	Danielle Skilton Flood Risk Consultant	Emily Craven Principal Consultant	Jon Robinson Operations Director
2	January 2014	Final Draft	Danielle Skilton Flood Risk Consultant	Emily Craven Principal Consultant	Jon Robinson Operations Director
3	May 2014	Final	Danielle Skilton Flood Risk Consultant	Emily Craven Principal Consultant	Jon Robinson Operations Director
4	June 2014	Final Revision	Danielle Skilton Flood Risk Consultant	Jon Robinson Operations Director	Jon Robinson Operations Director
5	April 2015	Updated with revised modelling for client comment	Sarah Littlewood Consultant	Matthew Ince Principal Flood Risk Consultant	Michael Timmins Technical Director
6	July 2015	Updated following client and consultation comments	Richard Karooni Flood Risk Engineer	Matthew Ince Principal Flood Risk Consultant	Elizabeth Gent Principal Consultant

URS Infrastructure & Environment UK Ltd.
6-8 Greencoat Place
London
SW1P 1PL
United Kingdom

Telephone: +44(0)20 7798 5000
Fax: +44(0)20 7798 5001

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EXECUTIVE SUMMARY

This document forms the updated Surface Water Management Plan (SWMP) for the London Borough of Hammersmith and Fulham (LBHF). This document is a plan which outlines the preferred surface water management strategy for the Borough including consideration of flooding from sewers, drains, groundwater, and runoff from land, small watercourses and ditches that occurs as a result of heavy rainfall.

The SWMP builds upon previous work undertaken at part of the Drain London Tier 1 and Tier 2 packages of work and has been undertaken following a four phase approach (as outlined in the Defra SWMP Technical Guidance, March 2010); Phase 1 – Preparation; Phase 2 – Risk Assessment; Phase 3 – Options; and Phase 4 – Implementation and Review.

Phase 1 Preparation

Phase 1 builds upon work formerly undertaken during Tier 1 and Tier 2 of the Drain London Project to collect and review surface water flood risk data from key stakeholders and build partnerships between stakeholders responsible for local flood risk management.

Phase 2 Risk Assessment

As part of Phase 2 Risk Assessment, direct rainfall modelling has been undertaken across the entire Borough for eight specified return periods. The results of this modelling have been used to identify flooding hotspots where flooding affects houses, businesses and/or infrastructure. The methodology for defining flooding hotspots specifically in LBHF is defined in Section 3.3.

In order to enable a more focused assessment of the surface water flood risk across the Borough, analysis of the modelling results and the number of properties at risk has been undertaken based on the 16 wards within the Borough, as identified in Figure 1.

Figure 1 – Maximum surface water flood depth (1% AEP) and ward boundaries

The chief mechanisms for flooding in the London Borough of Hammersmith and Fulham (LBHF) can be broadly divided into the following categories:

- *Runoff from higher topography* - The areas of greatest flood depths tend to be at the base of the steeper land to the north of the Borough.
- *Localised surface water runoff* – Within the central and southern parts of the borough, surface water flooding tends to be a result of localised ponding of surface water.
- *Sewer Flooding* – areas where extensive and deep surface water flooding is likely to be the influenced by sewer flooding. Where the sewer network has reached capacity and surcharged, this will exacerbate the flood risk in these areas.
- *Low Lying Areas* - areas such as underpasses, subways and lowered roads beneath railway lines are more susceptible to surface water flooding;
- *Railway Cuttings* - four stretches of mainline railway track (in cuttings) are susceptible to surface water flooding and, if flooded, will impact services that pass across the Borough;
- *Railway Embankments* - discrete surface water flooding locations along the up-stream side of the raised network rail embankments where water flows are interrupted and ponding can occur.

NORTH

College Park
Old Oak Common
North Acton
East Acton
Kensal Green
Queens Park
Maida Vale
West Kilburn
Kensal Town
Westbourne Green
North Kensington
PADDINGTON
Bayswater
Notting Hill
KENSINGTON
South Kensington
West Kensington
HAMMERSMITH
CHISWICK
Bedford Park
Brook Green
West Brompton
Walham Green
FULHAM
Parsons Green
Sands End
BARNES
River Thames

1 College Park and Old Oak
2 Wormholt and White City
3 Shepherd's Bush Green
4 Askew
5 Ravenscourt Park
6 Hammersmith Broadway
7 Addison
8 Avonmore and Brook Green
9 Fulham Reach
10 North End
11 Palace Riverside
12 Munster
13 Fulham Broadway
14 Town
15 Parsons Green and Walham
16 Sands End

0 0.5 1
kilometres

LEGEND

Surface Water Flood Depth (m)

- < 0.1m
- 0.1 - 0.25m
- 0.25 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- > 1.5m

- LBHF Administrative boundary
- Ward boundary
- Flooding hotspots

NOTES

Hydraulic modelling has been undertaken using linked 2D-1D hydraulic modelling software TUFLOW-ESTRY (ver 2012). Refer to the LBHF Model Build Report (2015) for further information on model limitations. The intended purpose of this drawing is to illustrate flood depth in areas in excess of 81m2. Due to the coarse nature of the data the results should not be used to examine flooding at property level.

As part of the SWMP, 'flooding hotspots' have identified which meet 1 of the following criteria:
Areas greater than 225 square metres defined as Significant hazard rating during the 1% AEP rainfall event.
Areas greater than 81 square metres defined as Extreme hazard rating during the 1% AEP rainfall event.
Areas greater than 81 square metres defined as Significant hazard rating during the 10% AEP rainfall event.

Version	FINAL	Scale at A3:	1:21,500
Drawn	SL	Checked	EG
Approved	EG	Date	11/03/15

Project Title
LONDON BOROUGH OF HAMMERSMITH AND FULHAM UPDATED SURFACE WATER MANAGEMENT PLAN

Drawing Title
MAXIMUM SURFACE WATER FLOOD DEPTH (1% AEP)

Client
h&f hammersmith & fulham

URS Infrastructure & Environment UK Ltd
6 - 8 Greencoat Place
London
SW1P 1PL
Tel. +44 (0)207 7985000
CAPITA URS
Flood Risk Management

Drawing Number
FIGURE 1

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Analysis of the number of properties predicted to be at risk of surface water flooding has been undertaken for the rainfall event with a 1 in 100 probability of occurrence in any given year (1% Annual Exceedance Probability, AEP).

A review of the results identifies that 7,059 residential properties and 889 non-residential properties in the LBHF could be at risk of surface water flooding of greater than 0.1m depth during a 1% AEP rainfall event. Of those, 845 residential properties and 64 non-residential properties could be at risk of flooding to a depth of greater than 0.5m during the same rainfall event.

Table 1 provides a breakdown of the number of properties at risk and the number of Council records of flooding within each Ward. Wards have been given ranked from most at risk (1) to least at risk (16).

Table 1 Analysis of surface water risk across LBHF Wards (1% AEP)

Ward (Ward ID)	Properties at risk of flooding >0.5m (1%AEP)		*Most deprived residential* properties at risk of flooding >0.5m (1%AEP)		Council records of flooding		Score
	Number	Rank	Number	Rank	Number	Rank	
Askew (4)	127	1	79	1	20	2	1.3
Hammersmith Broadway (6)	103	2	20	2	28	1	1.7
Addison (7)	80	4	15	5	12	4	4.3
Town (14)	86	3	0	10	10	5	6.0
Shepherd's Bush Green (3)	48	10	19	3	10	5	6.0
Wormholt and White City (2)	74	6	17	4	6	8	6.0
North End (10)	52	9	5	7	6	8	8.0
Ravenscourt Park (5)	79	5	9	6	3	14	8.3
Munster (12)	59	7	0	10	6	8	8.3
Parsons Green and Walham (15)	32	13	0	10	15	3	8.7
Fulham Broadway (13)	52	8	0	10	6	8	8.7
Avonmore and Brook Green (8)	36	11	0	10	9	7	9.3
Sands End (16)	29	14	5	7	5	12	11.0
Fulham Reach (9)	35	12	0	10	0	12	11.3
College Park and Old Oak (1)	13	15	1	9	2	16	13.3
Palace Riverside (11)	4	16	0	10	20	15	13.7

Analysis of this information by Ward indicates that flood risk is greatest in the western central part of the borough, including Askew, Wormholt and White City, Hammersmith Broadway and Addison. There is also a notable risk further south in the Town and Parsons Green and Walham.

The Council records of flooding support the findings of the surface water modelling, with significant number of records being reported in Askew, Parsons Green and Walham, Hammersmith Broadway and the Town.

Flooding in Wormholt and City and Askew is influenced by overland flows from the London Borough of Ealing. It is therefore important that the Councils work in partnership to manage flood risk at a catchment level in this area.

Phase 3 Options Assessment

There are a number of opportunities for flood risk management measures to be implemented across the Borough to tackle surface water flood risk. In addition, opportunities to raise community awareness of the risks and responsibilities for residents should be sought, and LBHF may wish to consider the implementation of a Communication Plan to assist with this.

Throughout the Borough there are opportunities for generic measures to be implemented through the establishment of a policy position on issues including the widespread use of SuDS and water conservation measures such as water butts and rainwater harvesting technology. In addition, there are Borough-wide opportunities to raise community awareness and improve resilience to flooding.

For each of the Wards, site-specific measures have been identified that could be considered to help manage surface water runoff across the Borough. Four options were shortlisted to be incorporated into the baseline modelling. These include:

- Borough wide implementation of street tree planters;
- Installation of green roof systems on suitable council buildings;
- Installation of permeable paving systems on all hardstanding council land; and,
- Development of flood storage basins within Wormwood Scrubs, Wendell Park and Wormholt Park.

Pluvial modelling undertaken as part of the SWMP has identified that flooding within the LBHF is heavily influenced by the sewer network. To address local flood risk in the LBHF it is recommended that, in the short to medium-term, LBHF work with Thames Water Utilities Ltd. to develop integrated solutions to surface water and sewer flood risk management.

Borough wide, it is recommended that LBHF:

- Engages with residents regarding the flood risk in the Borough, to make them aware of their responsibilities for property drainage (especially in the flooding hotspots) and the steps they can take to improve their flood resilience;
- Provides an ‘Information Portal’ via the LBHF website, for local flood risk information and measures that can be taken by residents to mitigate surface water flooding to / around their property; and,
- Prepares a Communication Plan to effectively communicate and raise awareness of surface water flood risk to different audiences using a clearly defined process for internal and external communication with stakeholders and the public.

Phase 4 Implementation and Review

Phase 4 establishes a long-term Action Plan for LBHF to assist in their role as a Lead Local Flood Authority (LLFA) under the Flood and Water Management Act (FWMA, 2010) to manage surface water flood risk across the Borough. In particular, the Action Plan can be used in the development of the Local Flood Risk Management Strategy which LBHF are required to prepare under the Act. The purpose of the Action Plan is to:

- Outline the actions required to implement the preferred options identified in Phase 3;
- Identify the partners or stakeholders responsible for implementing the action;
- Provide an indication of the priority of the actions and a timescale for delivery; and,
- Outline actions required to meet the requirements as LLFA under the FWMA 2010.

The SWMP Action Plan is a 'living' document, and as such, should be reviewed and updated regularly, particularly following the occurrence of a surface water flood event, or when additional data or modelling becomes available. Reviews should also be undertaken following any major development or changes in the catchment which may affect the surface water flood risk e.g. changes in the sewer network capacity.

GLOSSARY

Term	Definition
AEP	Annual Exceedance Probability - 10% AEP = 1 in 10 probability of occurrence in any given year - 5% AEP = 1 in 20probability of occurrence in any given year - 2% AEP = 1 in 50 probability of occurrence in any given year - 1.3% AEP = 1 in 75 probability of occurrence in any given year - 1% AEP = 1 in 100 probability of occurrence in any given year - 0.5% AEP = 1 in 200 probability of occurrence in any given year - 0.1% AEP = 1 in 1000 probability of occurrence in any given year
Aquifer	A source of groundwater comprising water bearing rock, sand or gravel capable of yielding significant quantities of water.
Asset Management Plan (AMP)	A plan for managing water and sewerage company (WaSC) infrastructure and other assets in order to deliver an agreed standard of service.
AStSWF	Areas Susceptible to Surface Water Flooding
Catchment Flood Management Plan	A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
CFMP	Catchment Flood Management Plan
CIRIA	Construction Industry Research and Information Association
Civil Contingencies Act	This Act delivers a single framework for civil protection in the UK. As part of the Act, Local Resilience Forums must put into place emergency plans for a range of circumstances including flooding.
CLG	Government Department for Communities and Local Government
Climate Change	Long term variations in global temperature and weather patterns caused by natural and human actions.
CSO	Combined Sewer Overflow
Culvert	A channel or pipe that carries water below the level of the ground.
Defra	Department for Environment, Food and Rural Affairs
DEM	Digital Elevation Model
DG5 Register	A water-company held register of properties which have experienced sewer flooding due to hydraulic overload, or properties which are 'at risk' of sewer flooding more frequently than once in 20 years.
DTM	Digital Terrain Model
EA	Environment Agency
Indicative Flood Risk Areas	Areas determined by the Environment Agency as indicatively having a significant flood risk, based on guidance published by Defra and WAG and the use of certain national datasets. These indicative areas are intended to provide a starting point for the determination of Flood Risk Areas by LLFAs.
FALP	Further Alterations to the London Plan
FCERM	Flood and Costal Erosion Risk Management
Flooding hotspots	A discrete area of flooding that affects houses, businesses or infrastructure. As part of the SWMP, flooding hotspots have been identified specifically for LBHF which meet one or more of the criteria set out in Section 3.3.
FMfSW	Flood Map for Surface Water
Flood defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Flood Risk Area	An area determined as having a significant risk of flooding in accordance with guidance published by Defra and WAG.

Term	Definition
Flood Risk Regulations	Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management.
Floods and Water Management Act (FWMA)	Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England.
Fluvial Flooding	Flooding resulting from water levels exceeding the bank level of a main river
FRR	Flood Risk Regulations (2009)
IDB	Internal Drainage Board
iPEG	(Area of) Increased Potential for Elevated Groundwater
IUD	Integrated Urban Drainage
LB	London Borough
LDF	Local Development Framework
Lead Local Flood Authority (LLFA)	Local Authority responsible for taking the lead on local flood risk management
LiDAR	Light Detection and Ranging
Local Resilience Forum (LRF)	A multi-agency forum, bringing together all the organisations that have a duty to cooperate under the Civil Contingencies Act, and those involved in responding to emergencies. They prepare emergency plans in a co-ordinated manner.
LPA	Local Planning Authority
MAFP	Multi-Agency Flood Plan
Main river	A watercourse shown as such on the main river map, and for which the Environment Agency has responsibilities and powers
MoU	Memorandum of Understanding
NPPF	National Planning Policy Framework (2012) – Government's planning policies for England.
NRD	National Receptor Dataset – a collection of risk receptors produced by the Environment Agency
Ordinary watercourse	All watercourses that are not designated main river, and which are the responsibility of Local Authorities or, where they exist, IDBs
Partner	A person or organisation with responsibility for the decision or actions that need to be taken.
Preliminary Flood Risk Assessment (PFRA)	Preliminary Flood Risk Assessment – Produced by LLFAs to fulfil statutory requirements of the FRR 2009.
Pitt Review	Comprehensive independent review of the 2007 summer floods by Sir Michael Pitt, which provided recommendations to improve flood risk management in England.
Pluvial Flooding	Flooding from water flowing over the surface of the ground; often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with additional flow.
PPS25	Planning and Policy Statement 25: Development and Flood Risk. Now replaced by the NPPF 2012.
Policy Area (PA)	A discrete area within an LPA administrative area where appropriate planning policy can be applied to manage flood risk. Primarily defined on a hydrological basis, but can also accommodate geological concerns where these significantly influence the implementation of SuDS
Resilience Measures	Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical appliances.
Resistance Measures	Measures designed to keep flood water out of properties and businesses; could include flood guards for example.
Risk	In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, and the consequence of the flood.

Term	Definition
Risk Management Authority (RMA)	As defined by the Floods and Water Management Act
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
Strategic Flood Risk Assessment (SFRA)	Strategic Flood Risk Assessment – refine information on the probability of flooding, taking other sources of flooding and the impact of climate change into account. They provide the basis for applying the Sequential Test and developing appropriate policies for flood risk management.
SLA	Service Level Agreement
SMP	Shoreline Management Plan
Stakeholder	A person or organisation affected by the problem or solution, or interested in the problem or solution. They can be individuals or organisations, includes the public and communities.
Sustainable Drainage Systems (SUDS)	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Surface water	Rainwater (including snow and other precipitation) which is on the surface of the ground (whether or not it is moving), and has not entered a watercourse, drainage system or public sewer.
Surface Water Management Plan (SWMP)	Surface Water Management Plan - A plan that outlines the preferred surface water management strategy in a given location. This definition of surface water includes flooding from sewers, drains, groundwater, and runoff form the land, small watercourses and ditches that occurs as a result of heavy rainfall.
TfL	Transport for London
TWUL	Thames Water Utilities Ltd
WaSC	Water and Sewerage Company

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1 INTRODUCTION

1.1 What is a Surface Water Management Plan?

1.1.1 A Surface Water Management Plan (SWMP) outlines the preferred surface water management strategy in a given location. In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, ordinary watercourses and ditches that occurs as a result of heavy rainfall.

1.1.2 This SWMP study has been undertaken as a 'follow on' from the Drain London Project[i] in consultation with key local partners who are responsible for surface water management and drainage in the London area. These include the Greater London Authority, Thames Water Utilities Ltd., the Environment Agency and Transport for London. The Partners have worked together to understand the causes and effects of surface water flooding so that they can agree the most cost effective way of managing surface water flood risk for the long term.

1.1.3 This document also establishes a starting point for a long-term action plan to manage surface water and will influence future capital investment, maintenance, public engagement and understanding, land-use planning, emergency planning and future developments.

1.2 Background

1.2.1 In May 2007 the Mayor of London consulted on a draft Regional Flood Risk Appraisal (RFRA). One of the key conclusions was that the threat of surface water flooding in London was poorly understood. This was primarily because there were relatively few records of surface water flooding and those that did exist were neither comprehensive nor consistent. Furthermore the responsibility for managing flood risk is split between Boroughs and other organisations such as Transport for London, London Underground, Network Rail, the Environment Agency and Thames Water Utilities Ltd. Relationships between surface water flooding and other sources of flood risk were also found to be unclear. To give the issue even greater urgency, it is widely expected that incidents of heavy rainfall will increase in frequency with climate change.

1.2.2 The Greater London Authority, London Councils, Environment Agency and Thames Water Utilities Ltd. commissioned a scoping study to test these findings and found that this was an accurate reflection of the situation. The conclusions were brought into sharp focus later in the summer of 2007 when heavy rainfall resulted in extensive surface water flooding in parts of the UK such as Gloucestershire, Sheffield and Hull causing considerable damage and disruption. Whilst not as severe as flooding in these locations, significant disruption was also caused in London. The Pitt Review examined the flooding of 2007 and made a range of recommendations for future flood management, most of these have been enacted through the Flood and Water Management Act (FWMA) 2010.

1.2.3 The Department for Environment, Food and Rural Affairs (Defra) recognised the importance of addressing surface water flooding in London and fully funded the Drain London project. The purpose of this project was to improve the knowledge of surface water drainage systems across London and identify the areas at greatest risk of flooding.

1.2.4 A first draft SWMP for the London Borough of Hammersmith and Fulham (LBHF) was completed 2011 (as part of Drain London Tier 2 described below). This report is an updated SWMP that has been completed to incorporate newly available data.

[i] Further information on the Drain London Project can be found here: http://www.london.gov.uk/drain-london

1.2.5 The Drain London project was delivered using a 'tier' based approach as shown in Figure 1.2-1.

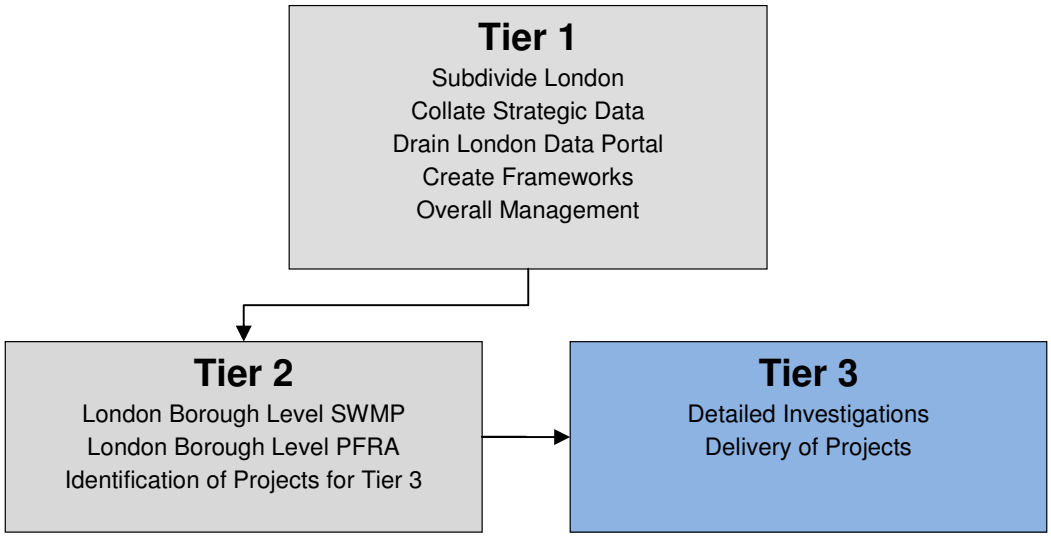


Figure 1.2-1 Drain London Project 'Tier' Structure

1.2.6 Table 1-1 further describes the activities undertaken in each of the Tiers. The management groups for Tier 2 of the Drain London project are shown in Figure 1.2-2; the LBHF is within Group 3 of the Drain London management group, and is grouped with the London Boroughs of Camden, City of Westminster, City of London and the Royal Borough of Kensington and Chelsea.

Table 1-1 Summary of Drain London 'Tier' Activities

Tier	Summary
Tier 1	a) A high level strategic investigation to group the 33 separate boroughs into a smaller number of more manageable units for further study under Tiers 2 and 3. b) Collection and collation of relevant information across all London Boroughs and strategic stakeholders including the Environment Agency, Thames Water Utilities Ltd. and Transport for London. c) Development of a web based 'Portal' to provide data management, data storage and access to the various data sets and information across the 'Drain London Forum' (DLF) participants and to consultants engaged to deliver Tiers 2 and 3. d) Develop technical framework documents and prioritisation tools to guide delivery of Tiers 2 and 3.
Tier 2	a) Delivery of 33 Borough-level intermediate Surface Water Management Plans (SWMPs) within the management groups to define and map areas at risk of flooding and flood policy areas, and produce an Action Plan for each borough. b) Delivery of 33 Borough-level Preliminary Flood Risk Assessments to comply with the Flood Risk Regulations 2009 requirements for Lead Local Flood Authorities (LLFAs). c) Define a list of prioritised areas for potential further study or capital works in Tier 3, using the prioritisation tool developed in Tier 1.

Tier	Summary
Tier 3	a) Further investigations into high priority areas to further develop and prioritise mitigation options. b) Delivery of demonstration projects of surface water flood mitigation solutions identified in Tier 2 SWMPs. c) Funding or co-funding within the London area for green roofs and other types of sustainable urban drainage (SuDS). d) Set up of at least 2 community flood plans in local communities at risk from flooding

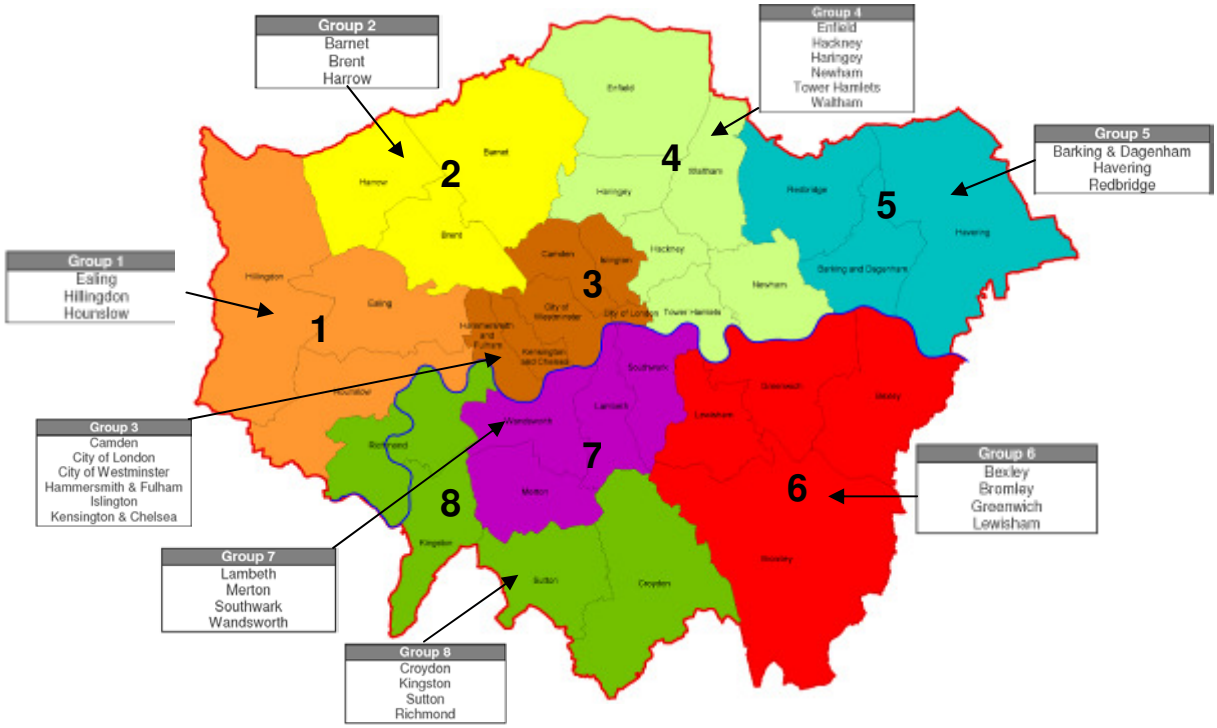


Figure 1.2-2 Drain London Management Groups

1.3 Objectives

1.3.1 The objectives of the SWMP are to:

- Develop a robust understanding of surface water flood risk in and around the study area, taking into account the challenges of climate change, population and demographic change and increasing urbanisation in London;
- Identify and map areas at risk of flooding including the identification of specific 'flooding hotspots';
- Make holistic and multifunctional recommendations for surface water management which improve emergency and land use planning, and enable better flood risk and drainage infrastructure investments;
- Establish and consolidate partnerships between key drainage stakeholders to facilitate a collaborative culture of data, skills, resource and learning sharing and exchange, and closer coordination to utilise cross boundary working opportunities;

- Undertake engagement with stakeholders to raise awareness of surface water flooding, identify flood risks and assets, and agree mitigation measures and actions;
- Deliver outputs to enable a real change on the ground rather than just reports and models, whereby partners and stakeholders take ownership of their flood risk and commit to delivery and maintenance of the recommended mitigation measures and actions; and
- Facilitate discussions and report implications relating to wider issues falling outside the remit of the Tier 2 work, but deemed important by partners and stakeholders for effectively fulfilling their responsibilities and delivering future aspects of flood risk management, for example, providing guidance on the responsibilities of LBHF as Lead Local Flood Authority (LLFA) under the FWMA 2010.

1.4 Study Area

Topography and Land Use

1.4.1 The study area is defined by the administrative boundary of the London Borough of Hammersmith and Fulham (LBHF), which is located in the north western part of Greater London. LBHF covers an area of approximately 16.4km^2 and is subdivided into 16 wards. LBHF sits between the London Borough of Brent to the north, the Royal Borough of Kensington and Chelsea to the east, the River Thames to the south and the London Boroughs of Ealing and Hounslow to the west. The Borough is traversed by the east-west A4 Great West Road and the A40 Westway connecting it to central London. The District, Piccadilly, Circle, Hammersmith and City and Central tube lines run through the Borough.

1.4.2 The LiDAR Topographic Survey Map (Figure 1.4-1) shows that the highest elevation within the Borough is in the north at approximately 45mAOD near Old Oak Common. The elevation decreases towards HMP Wormwood Scrubs and the A40 to the south. From the prison down to Parsons Green and the River Thames in the south, the Borough is largely flat, with a very slight decrease in elevation.

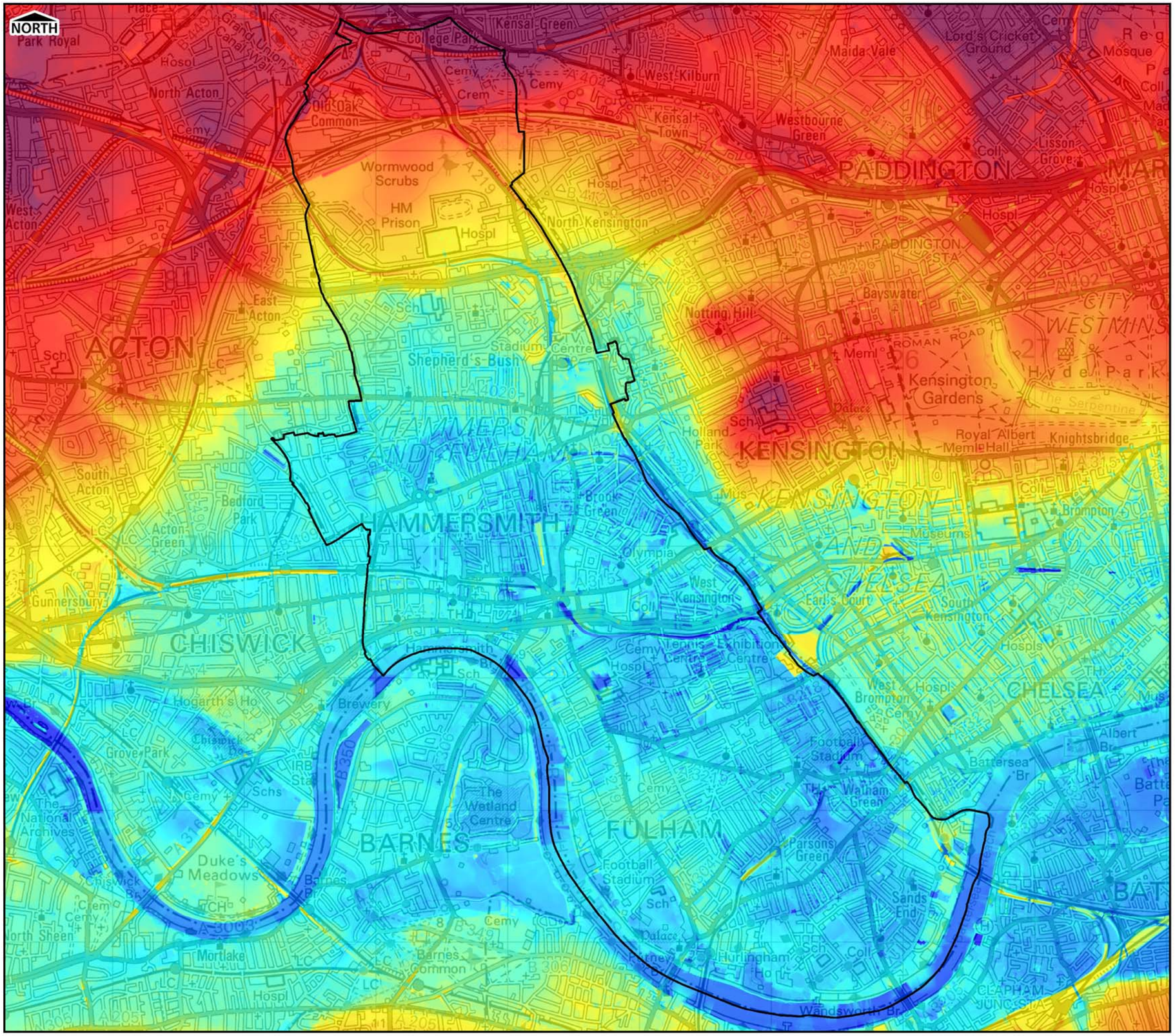
1.4.3 The bedrock geology (as shown in Appendix A, Figure A-5) is predominantly London Clay. Superficial deposits of sand and gravel (Kempton Park Gravel Formation) overlie the London Clay across the southern extent of the Borough (Goldhawk Road towards the River Thames). Superficial deposits of clay and silt (Langley Silt Member) overlie the London Clay across the area between Westway (A40) and Goldhawk Road, and around the area of Brook Green and Hammersmith Road.

1.4.4 The LBHF is heavily urbanised comprising predominantly residential and commercial land use as shown in Figure 1.4-2. Wormwood Scrubs, in the north of the Borough, is the largest of 16 parks within the Borough. This has an area of approximately 80 hectares, of which 42 hectares is a Designated Nature Conservation Area. The River Thames runs along the southern boundary of the Borough.

1.4.5 The study area falls into the Thames River Basin District (RBD) (as defined by the Environment Agency) and is located in the Environment Agency Thames Region. The water utility provider is Thames Water Utilities Ltd.

Figure 1.4-1 LiDAR Topographic Survey

Figure 1.4-2 Land Use Areas



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

LBHF Administrative Area

Elevation

- 0 mAOD
- 5 mAOD
- 10 mAOD
- 20 mAOD
- 30 mAOD
- 40 mAOD

London Borough of Hammersmith & Fulham

h&f hammersmith & fulham

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:30,000	Nov 2013	DS	EC

LiDAR Topographic Survey

Consultants

URS Infrastructure and Environment UK Ltd
6 - 8 Greencoat Place
London
SW1P 1PL

CAPITA | URS
Flood Risk Management

Figure 1.4-1

Version 2

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

LBHF Administrative Area

Land Use (Ordnance Survey)

- Roadside
- Road Or Track
- Buildings
- Path
- Manmade Structure
- General Surface: Manmade
- General Surface: Natural
- Natural Environment
- Rail
- Water

London Borough of Hammersmith & Fulham

h&f hammersmith & fulham

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
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Land Use Areas

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Flood Risk Management

Figure 1.4-2

Version 2

Flood Risk Overview

1.4.6 According to the Environment Agency's property count for their national Flood Map for Surface Water (FMfSW) dataset, approximately 29,400 properties are at risk of flooding across the UK during a rainfall event with a 1 in 200 probability of occurrence in any given year (0.5% Annual Exceedance Probability, AEP).

1.4.7 The LBHF was severely affected by surface water flooding in July 2007. The Met Office reported rainfall intensities in excess of 25mm/hr at many locations in the west with daily totals exceeding 100mm (compared to a monthly average rainfall of 44mm for July in the period 1971 to 2000). This short duration high intensity storm led to substantial overland flow and ponding of surface water in low lying areas. Drainage systems were overwhelmed in several locations across the Borough. Widespread damage and disruption was caused to residential and commercial properties.

1.4.8 Under United Kingdom Climate Projections 2009 (UKCP09), predictions for future rainfall in the UK up to 2080 are that there could be around three times as many days in winter with heavy rainfall (defined as more than 25mm in a day).

1.4.9 Within the Thames River Basin District, if emissions follow a medium future scenario, UKCP09 projected changes by the 2050s relative to the recent past are:

- Winter precipitation increases of approximately 15% (very likely to be between 2 and 32%);
- Precipitation on the wettest day in winter up by approximately 15% (very unlikely to be more than 31%);
- Relative sea level at Sheerness very likely to increase between 10 and 40cm from 1990 levels (not including extra potential rises from polar ice sheet loss);
- Peak river flows in a typical catchment likely to increase between 8 and 18%.

1.4.10 The risk of exceedance of the urban drainage system and surface water flooding in the Borough is therefore likely to increase into the future unless steps are taken to manage and mitigate this form of flooding.

Future Development

1.4.11 The London Borough of Hammersmith and Fulham's housing strategy is set out in policy H1 of the Borough's Core Strategy (October 2011). This outlines the aim to exceed the London Plan target of 615 additional properties a year up to 2021 and to continue to seek at least 615 additional dwelling a year up to 2032.

1.4.12 The Core Strategy has identified five key opportunity areas within the Borough, which are the focus of regeneration and redevelopment. The opportunity areas are:

a) White City Opportunity Area;
b) Hammersmith Town Centre and Riverside;
c) Fulham Regeneration Area (including Earls Court and West Kensington Opportunity Area);
d) South Fulham Riverside, and
e) Park Royal Opportunity Area.

1.4.13 Plans for urbanisation and redevelopment within the LBHF may present a challenge to the existing drainage systems. However, it is also affords a crucial opportunity to address long-standing issues and problems relating to surface water flooding and pressure points on the drainage system through strategic improvements and upgrades to the drainage system.

1.5 Flooding Interactions

1.5.1 In the context of SWMPs, surface water flooding incorporates flooding from sewers, drains, groundwater, and runoff from land, small watercourses (often referred to as ordinary watercourses) and ditches occurring as a result of heavy rainfall. These sources may operate independently or through a more complex interaction of several sources.

1.5.2 An initial overview of the flooding issues in the LBHF, based on historic flooding records in the Borough, indicate that several areas are affected by multiple sources of flood risk. These include complex interactions between direct surface water ponding, overland flow paths, and the combined sewer system. There are also several cross-boundary surface water flooding issues, with surface water and combined sewer flows from the London Borough of Ealing, London Borough of Brent and the Royal Borough of Kensington and Chelsea.

1.5.3 In order for these flooding mechanisms to be adequately assessed, a holistic approach to surface water management is required. The SWMP approach will seek to ensure that all sources and mechanisms of surface water flood risk are assessed and that solutions are considered in a holistic manner so that measures are not adopted that reduce the risk of flooding from one source to the detriment of another.

1.6 Linkages with Other Plans

1.6.1 The increased focus on flood risk over recent years is an important element of adaptation to climate change. It is important that the SWMP is not viewed as an isolated document, but one that connects with other strategic and local plans.

Regional Flood Risk Assessment (RFRA)

1.6.2 The London RFRA was produced in 2009 by the Greater London Authority (GLA). The RFRA provides a regional overview of flooding from all sources with the aim of informing Strategic Flood Risk Assessments and other local development plans. With the introduction of the National Planning Policy Framework, the RFRA is unlikely to be revised in future. Box 1.6-1 overleaf, highlights the strategic recommendations that are relevant to LBHF.

Box 1.6-1 RFRA Regional Policies and Strategy Recommendations Relevant to the LBHF

Regional Policies

Recommendation 1: Policies should be put in place to enable the sustainable and cost effective upgrade of river wall/embankments of properties near to the River Thames, in line with policy 5.12, CFMPs and TE2100.

Recommendation 5: Developments all across London should reduce surface water discharge in line with the Sustainable Drainage Hierarchy set out in Policy 5.13 of the London Plan (2011).

Recommendation 6: Regeneration and redevelopment of London's fluvial river corridors offer a crucial opportunity to reduce flood risk. SFRAs and policies should focus on making the most of this opportunity through appropriate location, layout and design of development as set out in PPS25 (superseded by NPPF) and the Thames CFMP. In particular opportunities should be sought to:

- Set back of development from the river edge to enable sustainable and cost effective flood risk management options
- Ensure that the buildings with residual flood risk are designed to be flood compatible or flood resilient
- Use open spaces within developments which have a residual flood risk to act as flood storage areas

Recommendation 8: Organisations responsible for development with large roof areas should investigate providing additional surface water run-off storage.

Recommendation 9: Thames Water Utilities Ltd. to continue the programme of addressing foul sewer flooding.

Recommendation 10: The groundwater flood risk is kept under review.

Recommendation 11: Network Rail should examine the London Rail infrastructure for potential flooding locations and flood risk reduction measures. For large stations, solutions should be sought to store or disperse rainwater from heavy storms; this may involve the need for offsite storage.

Recommendation 12: London Underground and DLR should keep potential flood risks to their infrastructure and flood risk reduction measures under review and up to date.

Recommendation 13: TfL, Highways Agency and London boroughs should continue to monitor the flood risk and flood risk reduction measures at these locations and any others with a potential flood risk.

Recommendation 18: Operators of London's emergency services should ensure that emergency plans for flooding incidents are kept up to date and suitable cover arrangements are in place in the event of a flood affecting operational locations.

Recommendation 19: Operators of electricity, gas, water and sewerage utility sites should maintain an up to date assessment of the flood risk to their installations and considering the likely impacts of failure, programme any necessary protection measures, this may include secondary flood defences.

Thames Catchment Flood Management Plan

1.6.3 The Thames Catchment Flood Management Plan was published in 2008 and sets out policies for the sustainable management of flood risk across the whole catchment over the long-term (50 to 100 years) taking climate change into account.

1.6.4 The Plan emphasises the role of the floodplain as an important asset for the management of flood risk, the crucial opportunities provided by new development and regeneration to manage risk, and the need to re-create river corridors so that rivers can flow and flood more naturally. More detailed flood risk management strategies for individual rivers or sections of river may sit under these.

1.6.5 This Plan will periodically be reviewed, to ensure that it continues to reflect any changes in the catchment.

Box 1.6-2 CFMP Policy Unit

TE2100 Policy Unit

The Thames Estuary 2100 Plan (TE2100) divides the floodplain of the tidal Thames into 23 separate policy units. The London Borough of Hammersmith and Fulham is part of the Hammersmith policy unit, Policy 5.

Policy 5 is to take further action to reduce flood risk beyond that required to keep pace with Climate Change. This means that the standard of protection against tidal flooding will be increased in the future. This will be achieved by improvements to the main tidal flood barrier on the Thames together with improvements to the other flood defences, e.g. river walls.

Specific actions in the TE2100 Plan that refer to the London Borough of Hammersmith and Fulham are as follows:

- To maintain, enhance or replace the existing river defence walls/banks and flood control structures;
- To incorporate the Riverside Strategy concept into local plans, strategies and guidance documents;
- To agree a programme of managing flooding from other sources in the defended tidal floodplain;
- To inform the development and revision of local council strategic flood risk assessments (SFRAs) and flood plans;
- To agree partnership arrangements and principles to ensure that new development in the tidal flood risk area is safe and, where possible, applies the NPPF to reduce the consequences of flooding;
- To agree partnership arrangements for floodplain management;
- To agree a programme of floodplain management.

The LBHF will work with the Environment Agency and others to ensure that the recommendations of the TE2100 Plan are implemented in new and existing developments, to keep communities safe from flooding in a changing climate and to improve the local environment.

Preliminary Flood Risk Assessment (PFRAs)

1.6.6 PFRAs are required as part of the Flood Risk Regulations which implement the requirements of the European Floods Directive in the UK. The PFRA is a high level assessment of flood risk, based on existing information on both historical floods and future flood risk from the sources of flooding other than main rivers, the sea and reservoirs, and their potential consequences on human health, economic activity, cultural heritage and the environment.

1.6.7 As part of the Drain London (Tier 2) Project, a PFRA has been produced for each London Borough (LLFA), to give an overview of all local sources of flood risk. In London PFRAs will benefit from an increased level of information relating to surface water from the Drain London SWMPs. Boroughs will need to review these PFRAs every 6 years.

1.6.8 The PFRA for the LBHF was completed and submitted to the Environment Agency in June 2011.

Surface Water Management Plans (SWMPs)

1.6.9 Drain London (Tier 2) produced a draft SWMP for each London Borough, including the LBHF. In addition they contain an Action Plan that has been developed in conjunction with both the Borough and relevant other Risk Management Authorities. The model outputs, actions and associated policy interventions will need to feed directly into the operational level of the Borough across many departments, in particular into spatial and emergency planning policies and designations and into the management of local authority controlled land.

1.6.10 This document forms the updated SWMP for the LBHF. This should be read in conjunction with the SWMPs for the Royal Borough of Kensington and Chelsea and the London Borough of Ealing, due to the cross-boundary nature of the surface water flood risk across the adjoining Boroughs.

Strategic Flood Risk Assessments (SFRAs)

1.6.11 Each local planning authority is required to produce a SFRA under the National Planning Policy Framework (NPPF). This provides an important tool to guide planning policies and land use decisions. The LBHF are in the process of updating their SFRA to incorporate the findings of this SWMP study.

Local Flood Risk Management Strategies

1.6.12 The FWMA 2010 requires each LLFA to produce a Local Flood Risk Management (LFRM) Strategy. This SWMP, the PFRA and their associated risk maps will provide the necessary evidence base to support the development of LFRM Strategies. No new modelling is anticipated to produce these strategies.

1.6.13 Figure 1.6-1 illustrates how the CFMP, PFRA, SWMP and SFRA link to and underpin the development of a LFRM Strategy.

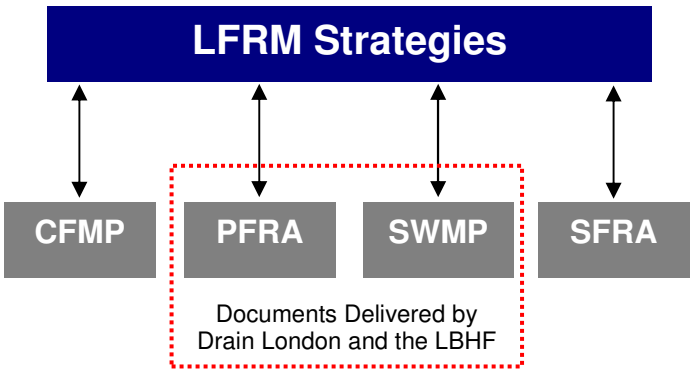


Figure 1.6-1 Schematic Diagram of Development of LFRM Strategies

River Basin Management Plans (RBMPs)

1.6.14 The River Basin Management Plan for the Thames River Basin District addresses the pressures facing the water environment in the district and the actions required to protect and improve the water environment. This plan has been developed in consultation with a wide range of organisations and individuals and is the first of a series of six-year planning cycles. The first cycle will end in 2015 when, following further planning and consultation, this SWMP should be reviewed and updated/reissued as required.

Local Development Framework (LDF)

1.6.15 The LDF includes the Core Strategy, Development Management Local Plan and Planning Guidance Supplementary Planning Document, and will need to reflect the results from the SWMP. This may include policies for the whole Borough, specific Wards, or cross-Borough issues. The SFRA and SWMP will assist with this as will the reviewed RFRA and any updated London Plan policies. In producing Opportunity Area Planning Frameworks, the GLA and Boroughs will also examine surface water flood risk more closely.

1.6.16 The LBHF Core Strategy has been through public consultation and examination and was adopted in October 2011. The LBHF Development Management Local Plan was adopted in July 2013. Revisions to some of the policies are planned in 2014/2015. These will take account of the findings of the updated SWMP and SFRA.

LBHF Water Management Policy

1.6.17 The LBHF Water Management Policy document sets out the need for an integrated approach to water management within urban areas. The document outlines a number of recommendations for surface water management, including the identification of potential opportunities for implementation of SuDS and Green Infrastructure.

1.7 Existing Legislation

1.7.1 The FWMA 2010 presents a number of challenges for policy makers and the flood and coastal risk management authorities identified to co-ordinate and deliver local flood risk management (surface water, groundwater and flooding from ordinary watercourses). 'Upper Tier' local authorities have been empowered to manage local flood risk through new responsibilities for flooding from surface and groundwater.

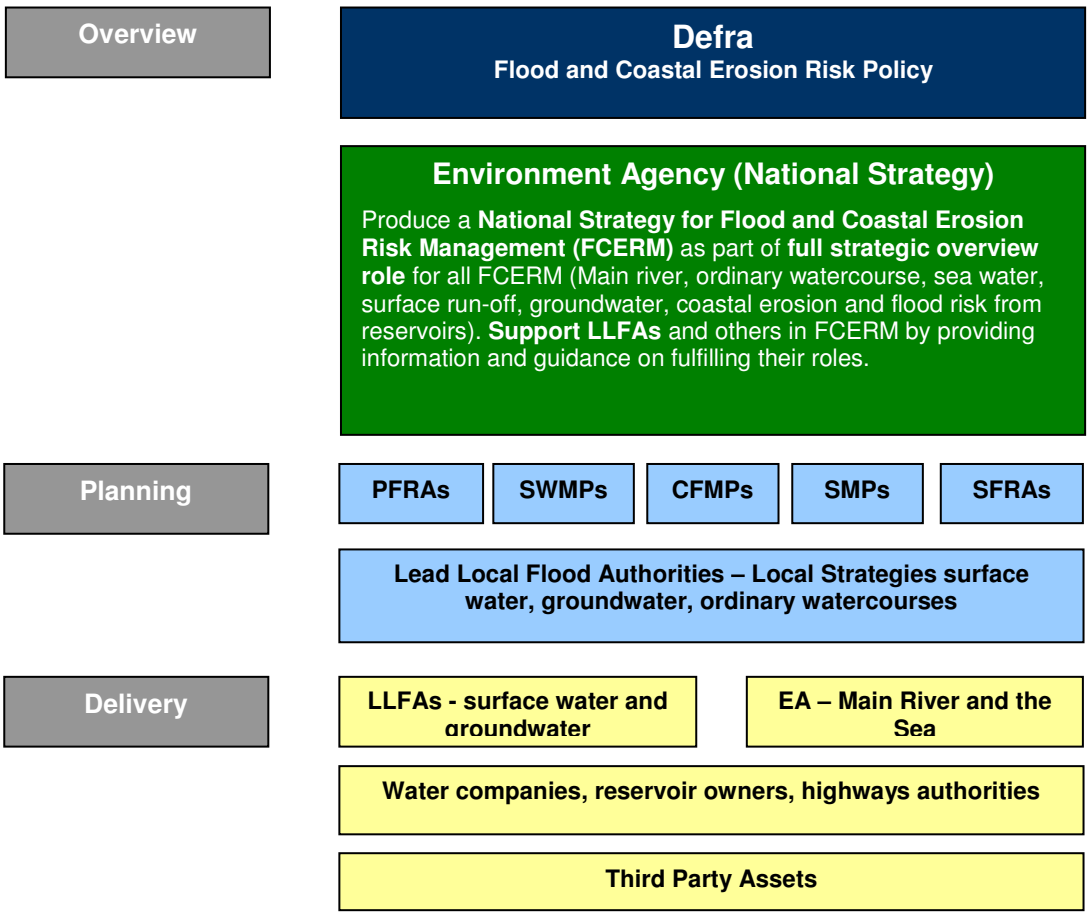
1.7.2 The FWMA 2010 reinforces the need to manage flooding holistically and in a sustainable manner. This has grown from the key principles within Defra's 'Making Space for Water' and was further reinforced by the summer 2007 floods and the Pitt Review. It implements several key recommendations of Sir Michael Pitt's Review of the summer 2007 floods, whilst also protecting water supplies to consumers and protecting community groups from excessive charges for surface water drainage.

1.7.3 The FWMA 2010 must also be considered in the context of the EU Floods Directive, which was transposed into law by the Flood Risk Regulations 2009 (FRR) on 10 December 2009. The FRR 2009 requires three main types of assessment / plan:

- PFRAs (maps and reports for surface water, ordinary watercourses and groundwater (LLFA) and main rivers, sea and reservoirs (Environment Agency) flooding- to be completed by the 22 December 2011. Flood Risk Areas, at potentially significant risk of flooding, will also be identified. Maps and management plans will be developed on the basis of these flood risk areas.
- Flood Hazard Maps and Flood Risk Maps - the Environment Agency and LLFAs are required to produce Hazard and Risk maps for surface water, ordinary watercourses and groundwater (LLFAs) and sea, main river and reservoir (Environment Agency) flooding as well as 'other' relevant sources by 22 December 2013.
- Flood Risk Management Plans - the Environment Agency and LLFAs are required to produce Flood Risk Management Plans for surface water, ordinary watercourses and groundwater (LLFAs) and sea, main river and reservoir (Environment Agency) flooding as well as 'other' relevant sources by 22 December 2015.

1.7.4 Figure 1.7-1 illustrates how this SWMP fits into the delivery of local flood and coastal risk management, and where the responsibilities for this lie.

Figure 1.7-1 Delivery of Local Flood and Coastal Risk Management



1.7.5 Aside from forging partnerships and coordinating and leading on local flood management, there are a number of other key responsibilities that have arisen for LLFAs from the FWMA 2010, and the Flood Risk Regulations 2009. These responsibilities include those listed in Table 1-2.

Table 1-2 LLFA Responsibilities under FWMA 2010

Responsibility	Description
Forge Partnerships and Coordinate and Lead on Local Flood Management	LLFAs have a duty to lead on local flood risk management, including establishing effective partnerships within their local authority as well as with external stakeholders such as the Environment Agency, Thames Water Utilities Ltd, Transport for London, Network Rail and London Underground as well as others.
Investigate Flood Incidents	LLFAs have a duty to investigate and record details of significant flood events within their area. This duty includes identifying which authorities have flood risk management functions and what they have done or intend to do with respect to the incident, notifying risk management authorities

Responsibility	Description
	where necessary and publishing the results of any investigations carried out.
Maintain Asset Register	LLFAs also have a duty to maintain a register of structures or features which are considered to have an effect on flood risk, including details on ownership and condition as a minimum. The register must be available for inspection and the Secretary of State will be able to make regulations about the content of the register and records.
SuDS Approving Body	LLFAs are designated the Sustainable Drainage Systems (SuDS) Approving Body (SAB) for any new drainage system, and therefore must approve, adopt and maintain any new SuDS within their area. The date for this policy to become mandatory has not yet been confirmed, however, some councils are now approving and adopting SuDS on a trial basis to assist in setting up and improving internal procedures.
Local Flood Risk Management (LFRM) strategies	LLFAs are required to develop, maintain, apply and monitor a strategy for local flood risk management in its area. The LFRM strategy will build upon information such as national risk assessments and will use consistent risk based approaches across different local authority areas and catchments.
Works Powers	LLFAs have powers to undertake works to manage flood risk from surface runoff and groundwater, consistent with the LFRM strategy for the area.
Designation powers	LLFAs, as well as district councils and the Environment Agency have powers to designate structures and features that affect flooding in order to safeguard assets that are relied upon for flood risk management. Once a feature is designated, the owner must seek consent from the authority to alter, remove or replace it.

1.7.6 The partnerships forged and outcomes of the SWMP will assist LBHF, as an LLFA, in starting to deliver their requirements under the FWMA 2010 and Flood Risk Regulations 2009. In particular, through the SWMP production and Drain London project, LBHF has established both internal and external partnerships in managing local flood risk, put in place the structures for recording flooding incidents and producing an asset register, and, through the delivery of an SWMP and PFRA (and associated flood risk depth and hazard maps), provided the necessary evidence base to support the development of LFRM Strategies. The key actions to deliver the requirements of the FWMA are included within the Action Plan in Appendix E.

Recommendation 1: Continue to work towards fulfilling the requirements under the Flood and Water Management Act 2010 and Flood Risk Regulation 2009.

2 PHASE 1: PREPARATION

2.1 Partnership

2.1.1 In order for the SWMP and, more general future flood risk management within the LBHF to be successful, it is essential that relevant partners and stakeholders, who share the responsibility for necessary decisions and actions, work collaboratively to understand existing and future surface water flood risk in the Borough.

2.1.2 The FWMA 2010 defines the unitary authority, in this instance the LBHF, as the LLFA. As such, the LBHF is responsible for leading local flood risk management, including establishing effective partnerships within their local authority as well as with external stakeholders such as the Environment Agency, Thames Water Utilities Ltd, Transport for London, Network Rail and London Underground as well as others. Ideally these working arrangements should be formalised to ensure clear lines of communication, mutual co-operation and management through the provision of Service Level Agreements (SLA) or Memorandums of Understanding (MoU).

Recommendation 2: Establish a Flood Risk Management Group for the LBHF (as LLFA) to take forward FWMA and SWMP actions and Local Flood Risk Management.

Recommendation 3: Ensure required skills and capacity are in place within (or between) LLFA(s) to deliver FWMA and Local Flood Risk Management requirements.

Stakeholder Engagement

2.1.3 As part of the preparation of PFRAs and SWMPs across London, stakeholders have been engaged representing the following organisations and authorities:

- Environment Agency
- Thames Water Utilities Ltd
- Neighbouring London Boroughs
- Canal and River Trust
- London Fire Brigade
- British Geological Society
- Network Rail
- London Underground
- Transport for London
- Highways Agency
- Natural England

Public Engagement

2.1.4 Members of the public may also have valuable information to contribute to the SWMP and to an improved understanding and management of local flood risk within the study area. Public engagement can afford significant benefits to local flood risk management including building trust, gaining access to additional local knowledge and increasing the probability of stakeholder acceptance of options and decisions proposed in future flood risk management plans.

2.1.5 However, it is also recognised that it is crucial to plan the level and timing of engagement with communities predicted to be at risk of flooding from surface water, groundwater and ordinary watercourses. This is to ensure that the potential for future management options and actions is adequately understood and costed without raising expectations before solutions can reasonably be implemented.

2.1.6 It is important to undertake some public engagement when formulating local flood risk management plans (including LFRM Strategies) as this will help to inform future levels of public engagement. It is recommended that LBHF follow the guidelines outlined in the Environment Agency's "Building Trust with Communities" which provides a useful process of how to communicate risk including the causes, probability and consequences to the general public and professional forums such as local resilience forums.

Recommendation 4: Actively engage with members of the public regarding local flood risk management and formulation of the LFRM Strategy.

2.2 Data Collection

2.2.1 One of the key components of a shared understanding of flood risk is the sharing of flood risk data and knowledge between and across organisations. The collection and collation of strategic level data was undertaken as part of the Drain London Tier 1 work and disseminated to Drain London Tier 2 consultants by the GLA. Data was collected from each of the following organisations:

- London Borough of Hammersmith and Fulham
- Royal Borough of Kensington and Chelsea
- Environment Agency
- Thames Water Utilities Ltd
- Transport for London
- Network Rail
- Canal and River Trust

2.2.2 Table 2-1 provides a summary of the main data sources held by partner organisations used in the preparation of the SWMP.

Table 2-1 Data Sources

Data Supplier	Dataset	Description
London Borough of Hammersmith and Fulham	Ordnance Survey Mapping (1:10k, 1:50k, Mastermap)	Ordnance Survey Mapping for the LBHF area for the 1:10k and 1:50k scale and Mastermap dataset.
	Core Strategy	Identification of growth areas within LBHF.
	Historical flooding records	Historical records of flooding from surface water, groundwater and ordinary watercourses.
	Details of gully locations	GIS dataset containing locations of gullies across the LBHF area.
	Details of major planning applications	Details of all major planning applications within LBHF, submitted within the last 5 years.
	Details of recent developments	Details of recent developments including details of development type.
Environment Agency	Environment Agency Flood Map (Fluvial)	Shows the extent of flooding from rivers with a catchment of more than 3km^2 and from the sea.
	Detailed River Network	Shows the locations of main rivers, other rivers and offline ditches across the area.
	Areas Susceptible to Groundwater Flooding	Mapping showing areas susceptible to groundwater flooding across the area.
	Flood Map for Surface Water	A second generation of surface water flood mapping which was released at the end of 2010.
	National Receptors Dataset	A nationally consistent dataset of social, economic, environmental and cultural receptors including residential properties, schools, hospitals, transport infrastructure and electricity substations.
	Historic Flood Map	Attributed spatial flood extent data for flooding from all sources.
	LiDAR topographic data	2m, 1m, 50cm and 25cm resolution terrain model compiled from aerial surveys in 2002, 2004 and 2006
Thames Water Utilities Limited	DG5 Register for Thames Water Utilities Ltd. areas	DG5 Register logs and records of properties at risk of flooding from sewers. The dataset supplied provides those properties on the register in June 2014.

Data Supplier	Dataset	Description
	Thames Water Sewer Network and Asset Location	The Thames Water Utilities Ltd. Sewer network shows the location and size of the foul, combined, surface water and storm relief sewers across the LBHF area along with the locations, pipe sizes and inverts for Sewage Treatment Works, Pumping Stations and Combined Sewer Overflows.
Greater London Authority	Increased Potential for Elevated Groundwater (iPEG)	GIS dataset of areas of increased potential for elevated groundwater (iPEG), produced using existing Environment Agency, BGS and Jacobs / JBA datasets, produced for the Greater London area for the purpose of assessing groundwater flood risk as part of the Drain London project.
Network Rail	Rail network and track drainage assets	GIS files containing drainage assets across the LBHF area.
	Rail network maintenance regions	GIS later of maintenance regions.
Transport for London (TfL)	TfL Flood Records	Records of flooding from highways call centre and spread sheet containing details of flood depths within the LBHF.
	TfL Gullies	Spread sheet of the TfL owned / managed gullies along the Red Routes for the LBHF.
	TfL Channels	Spread sheet of the TfL owned / managed channels along the Red Routes for the LBHF.
	TfL Pumps	Location and pump regimes for TfL owned / managed gullies in the LBHF.
Canal and River Trust	Canal Locations	Dataset detailing the locations of canals within the LBHF.

Security, Licensing and Use Restrictions

2.2.3 A number of datasets used in the preparation of this SWMP are subject to licensing agreements and use restrictions.

2.2.4 The following national datasets provided by the Environment Agency are available to local authorities and their consultants for emergency planning and strategic planning purposes:

- Flood Map for Rivers and the Sea
- Areas Susceptible to Surface Water Flooding
- Areas Susceptible to Groundwater Flooding
- Flood Map for Surface Water
- National Receptor Database

2.2.5 A number of the data sources used are publicly available documents, such as:

- Strategic Flood Risk Assessment
- Catchment Flood Management Plan

2.2.6 The use of some of the datasets made available for this SWMP has been made restricted. These include:

- Records of properties flooded held by LBHF; and
- Records of flooding by Thames Water Utilities Ltd.

2.2.7 Necessary precautions must be taken to ensure that all information given to third parties is treated as confidential. The information must not be used for anything other than the purpose stated in the agreement. No information may be copied, reproduced or reduced to writing, other than what is necessary for the purpose stated in the agreement.

3 PHASE 2: RISK ASSESSMENT

3.1 Detailed Assessment

3.1.1 As shown in Table 3-1, a detailed assessment has been completed to describe the causes and consequences of flooding as well as to test potential mitigation measures through hydraulic modelling of surface and sub-surface drainage systems.

3.1.2 Discussion with the Council, Thames Water Utilities Ltd. and local residents has concluded that detailed hydraulic modelling is required to better represent the flood mechanisms that operate within the LBHF. The detailed modelling includes the refinement of the rainfall for the area, a review of the critical storm duration, refined grid model cell size and inclusion of the gulley and drainage network across the Borough.

3.1.3 The LBHF SWMP Baseline Model Build Report (2013) outlines the model build process and discussion of the model results. This should be referenced to for more detail as to the model build and verification process.

3.1.4 The outputs from this SWMP modelling assessment should be used to inform spatial and emergency planning. The outputs can also be used to identify potential mitigation measures which can be implemented in order to reduce surface water flood risk. These may include quick win measures such as improving maintenance and clearing blockages/obstruction to the drainage infrastructure.

Table 3-1 SWMP Study Levels of Assessment (Defra, 2010)

Level of Assessment	Appropriate Scale	Outputs
1. Strategic Assessment	Greater London	Broad understanding of locations that are more vulnerable to surface water flooding. Prioritised list for further assessment. Outline maps to inform spatial and emergency planning.
2. Intermediate Assessment	Borough wide	Identify flood hotspots which might require further analysis through detailed assessment. Identify immediate mitigation measures which can be implemented. Inform spatial and emergency planning.
3. Detailed Assessment	Known flooding hotspots or incorporating greater detail.	Detailed assessment of cause and consequences of flooding. Use to understand the mechanisms and test mitigation measures, through modelling of surface and sub-surface drainage systems.

3.2 Risk Overview

3.2.1 The following sources of flooding have been assessed and are described in greater detail in the following sections of the report.

- Surface water flooding results from rainfall that fails to infiltrate the surface and travels over the ground surface; this is exacerbated where the permeability of the ground is low due to the type of soil and geology (such as clayey soils) or urban development.

Surface water flow is also promoted in areas of steep topography which can rapidly convey water that has failed to penetrate the surface.

- Sewer flooding generally results in localised short term flooding caused by intense rainfall events overloading the capacity of sewers. Flooding can also occur as a result of blockage, poor maintenance or structural failure.
- Groundwater flooding occurs where groundwater levels rise above ground surface levels. Local geology has a major influence on where this type of flooding takes place; it is most likely to occur in low-lying areas underlain by permeable rocks (aquifers).

3.3 Areas of Flood Risk

3.3.1 Areas of flood risk are defined at varying scales from London-wide definitions to more localised definitions of areas at risk. The following terminology has been used in the SWMP:

3.3.2 **Indicative Flood Risk Areas**: Areas determined by the Environment Agency as indicatively having a significant flood risk, based on guidance published by Defra and WAG and the use of certain national datasets (such as the update Flood Map for Surface Water). These are to be used by Lead Local Flood Authorities as part of the process for identifying Flood Risk Areas under the Flood Risk Regulations as set out in the Environment Agency and Defra and WAG guidance on PFRAs. One Indicative Flood Risk Area covers approximately the entire Greater London Area.

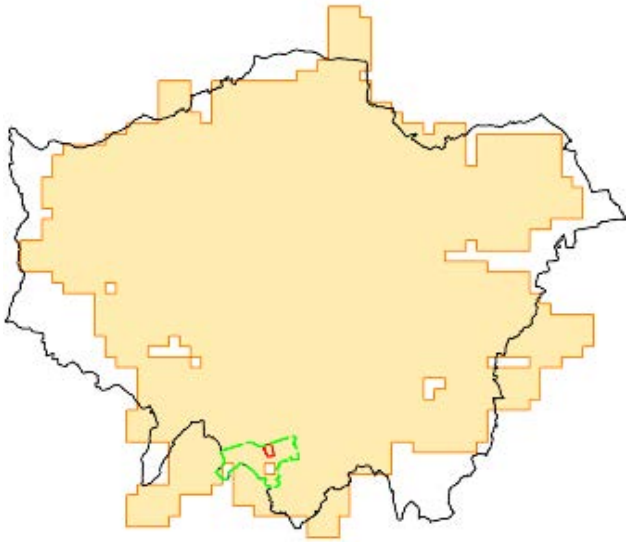
3.3.3 **Policy Areas**: A discrete area within an LPA administrative area where appropriate planning policy can be applied to manage flood risk.

3.3.4 **Wards**: Subdivisions of the LBHF administrative area. Due to the presence of surface water flood risk across the entire administrative area of LBHF, and the existing use of Wards for the purpose of organising maintenance and upgrade works, flood risk within LBHF has been analysed by Ward. Wards contain multiple flooding hotspots, which are managed at the Ward level.

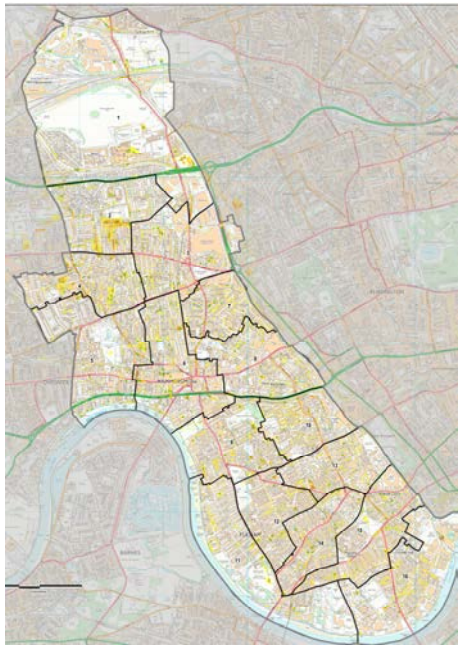
3.3.5 **Flooding Hotspots**: A discrete area of flooding that affects houses, businesses or infrastructure. As part of the SWMP, flooding hotspots have been identified specifically for LBHF which meet one of the following criteria:

- Areas greater than 225 square metres defined as Significant hazard rating during the 1% AEP rainfall event.
- Areas greater than 81 square metres defined as Extreme hazard rating during the 1% AEP rainfall event.
- Areas greater than 81 square metres defined as Significant hazard rating during the 10% AEP rainfall event.

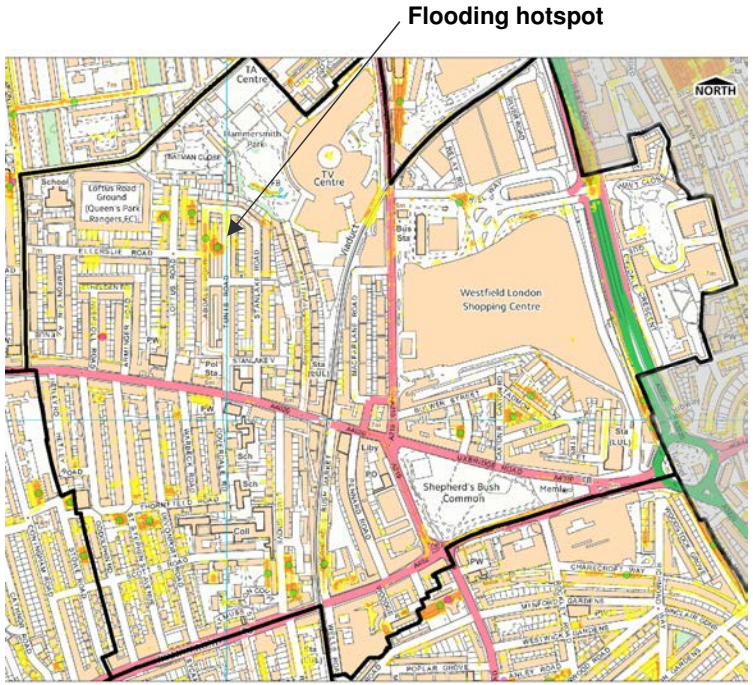
3.3.6 Examples of these areas are shown in Figure 3.3-1 and further information is provided in Table 3-2.



Indicative Flood Risk Area (Greater London)



Borough and Ward boundaries



Ward boundary and flooding hotspots

Figure 3.3-1 SWMP Definitions

Table 3-2 SWMP Flood Risk Management Areas

Scale	Definition	Description	LBHF Specific Areas	
Flooding hotspot	*"Discrete areas of flooding that affect houses, businesses or infrastructure".*	As part of the SWMP, flooding hotspots have been identified specifically for LBHF which meet one of the following criteria: Areas greater than 225 square metres defined as Significant hazard rating during the 1% AEP rainfall event. Areas greater than 81 square metres defined as Extreme hazard rating during the 1% AEP rainfall event. Areas greater than 81 square metres defined as Significant hazard rating during the 10% AEP rainfall event.	1 College Park and Old Oak (39 flooding hotspots) 2 Wormholt and White City (26 flooding hotspots) 3 Shepherd's Bush (19 flooding hotspots) 4 Askew (25 flooding hotspots) 5 Ravenscourt Park (18 flooding hotspots) 6 Hammersmith Broadway (34 flooding hotspots) 7 Addison (22 flooding hotspots) 8 Avonmore and Brook Green (4 flooding hotspots)	9 Fulham Reach (18 flooding hotspots) 10 North End (11 flooding hotspots) 11 Palace Riverside (11 flooding hotspots) 12 Munster (12 flooding hotspots) 13 Fulham Broadway (10 flooding hotspots) 14 Town (21 flooding hotspots) 15 Parsons Green and Walham (8 flooding hotspots) 16 Sands End (9 flooding hotspots)
Ward	*A discrete administrative area containing multiple flooding hotspots that are collectively managed at the Ward level.*	Ward areas are currently used by LBHF to plan regular maintenance of gully infrastructure and responding to reports of flooding. Wards areas should be used to collectively manage clusters of flooding hotspots, for site specific detailed planning and for future capital works schemes.	1 College Park and Old Oak 2 Wormholt and White City 3 Shepherd's Bush 4 Askew 5 Ravenscourt Park 6 Hammersmith Broadway 7 Addison 8 Avonmore and Brook Green	9 Fulham Reach 10 North End 11 Palace Riverside 12 Munster 13 Fulham Broadway 14 Town 15 Parsons Green and Walham 16 Sands End
Policy Area (PA)	*"A discrete area within an administrative area where appropriate planning policy can be applied to manage flood risk."*	Policy Areas may cover more than one Ward. Policy Areas are primarily based on hydrological catchments but may also accommodate geological concerns and other factors as appropriate. Policy areas may be used to provide guidance on general policy across the study area e.g. the use of soakaways in new development.	Given the complex and interlinked surface water flooding within the LBHF, it has been agreed that only one Policy Area should be defined in the LBHF, covering the entire administrative area.	
Indicative Flood Risk Area	*"Areas determined by the Environment Agency as indicatively having a significant flood risk, based on guidance published by Defra and WAG and the use of certain national datasets."*	Indicative Flood Risk Areas are defined by the Environment Agency / Defra primarily for the purposes of the preparation of PFRAs.	The Greater London Area has been identified as an Indicative Flood Risk Area, with 696,805 people at risk from surface water flooding deeper than 0.3 metres during the 0.5% AEP rainfall event (based on FMfSW outputs).	

3.4 Surface Water Flooding

Overview

3.4.1 Surface water flooding occurs when high intensity rainfall generates runoff which flows over the surface of the ground and ponds in low lying areas, before the runoff enters any watercourse or sewer. It is usually associated with high intensity rainfall events and can be exacerbated when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with the additional flow.

3.4.2 No single organisation has overall responsibility for surface water flooding with different aspects of the drainage system falling to the Highway Authority (in this case LBHF), Thames Water Utilities Ltd. And Transport for London (red routes).

Historical Flooding

3.4.3 LBHF has provided a GIS dataset of recorded flooding incidents, predominantly from the July 2007 flood event. These are the only historical surface water flooding records held by the Council. These records are shown in Figure A-1 of Appendix A. In many cases the historic flooding information provided is anecdotal and does not include records of flood depth or cause of flooding.

3.4.4 The most recent significant flood event occurred during July 2007, when intense periods of rainfall exceeded the capacity of existing drainage systems, causing significant overland flow and ponding of surface water in low lying areas. Many areas were affected including Sands End, Parsons Green, Fulham, Brook Green and the Cathnor Park area.

3.4.5 The July 2007 summer rainfall event has been used to validate hydraulic baseline modelling used to inform this SWMP. Details of this process can be found in the Baseline Model Build Report (2013).

Recommendation 5: Implement a standardised Flood Incident Log to record and investigate future flooding incidents.

Surface Water Modelling

3.4.6 In order to continue developing an understanding of the causes and consequences of surface water flooding in the study area, detailed hydraulic modelling has been undertaken for a range of rainfall event probabilities. This hydraulic modelling has been designed to represent the interaction between surface water and sewer flooding within the Borough.

3.4.7 A Direct Rainfall approach using TUFLOW software has been selected whereby rainfall events of known probability are applied directly to the ground surface and is routed overland to provide an indication of potential flow path directions and velocities and areas where surface water will pond.

3.4.8 An integrated 1D – 2D model has been developed in ESTRY - TUFLOW to determine the interactions between surface and sewer flooding mechanisms within the LBHF. The baseline model has developed from the Drain London Tier 2 modelling to include the following enhancements:

- Incorporating the Thames Water Utilities Ltd. combined sewer network across the LBHF model area with representation of the foul component of flow.

- The use of catchment specific rainfall profiles and critical storm durations.
- Increase in the 2D model resolution from 5m to 3m to allow for a better representation of topographic features that influence overland flow paths.
- Incorporation of key structures that influence the flow of surface water including railway culverts, embankments, underpasses and road structures.
- Development of a methodology for improved representation of the anticipated flooding mechanisms for basement properties.

3.4.9 A full methodology of the hydraulic modelling undertaken is presented in the LBHF SWMP Baseline Model Build Report (URS April 2015) including details of an independent modelling review.

3.4.10 Figures 3.4-1 and 3.4-2 show the modelling results for LBHF baseline model for the rainfall event with a 1% AEP for maximum flood depth and hazard rating[ii], respectively.

Figure 3.4-1 Maximum Surface Water Flood Depth (1% AEP)

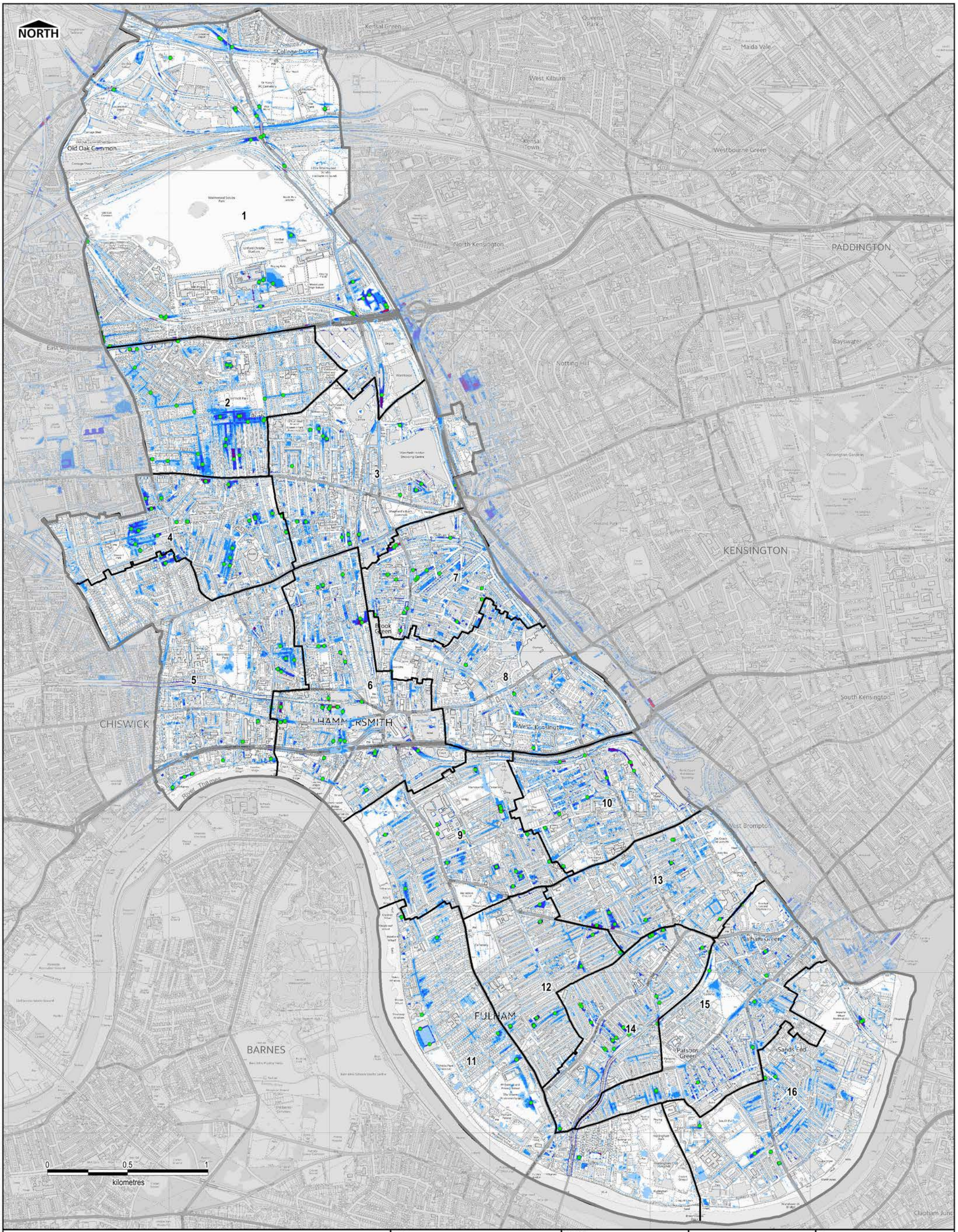
Figure 3.4-2 Surface Water Flood Hazard Rating (1% AEP)

3.4.11 Figures for the other return periods are included in Appendix A. A summary of the suggested uses for each mapped output is provided in Table 3-3.

Table 3-3 Modelled Return Periods and Suggested Use

Modelled Return Period	Suggested Use
10% AEP Figure A-6a&b	Verifying hydraulic model outputs against Thames Water Utilities Ltd. DG5 register and Counters Creek standard model runs.
5% AEP Figure A-7a&b	Thames Water Utilities Ltd. use this return period to identify properties that may be at risk of flooding. This return period correlates to the 'very significant' flood risk as part of the flood and coastal erosion risk management Grant in Aid (FCRM GiA).
3.3% AEP Figure A-8a&b	Sewers for Adoption (2006) requires Thames Water Utilities Ltd. to design sewers to accommodate 3.3% rainfall event or less. This output should be used to determining benefit of flood risk management options should partnership funding with Thames Water Utilities Ltd. be sought. This also corresponds to the updated Flood Map for Surface Water (uFMfSW) 1 in 30 year dataset being prepared by the Environment Agency.
2% AEP Figure A-9a&b	For use in determining benefit of flood risk management options, should partnership funding with Thames Water Utilities Ltd be sought.

[ii] Flood Hazard has been defined based upon the joint Environment Agency and Defra Research and Development Technical Report FD2320 (January 2006) and uses surface water flood depths and velocities to categorise the flood hazard. The degree of flood hazard can be interpreted as follows: (a) Caution: Flood zone with shallow flowing water or deep standing water; (b) Moderate: Flood zone with deep or fast flowing water. Dangerous for children, the elderly and the infirm; (c) Significant: Flood zone with deep fast flowing water. Dangerous for most people; and, (d) Extreme: Flood zone with deep fast flowing water. Dangerous for all (including emergency services)



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LEGEND

Surface Water Flood Depth (m)

- < 0.1m
- 0.1 - 0.25m
- 0.25 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- > 1.5m

- LBHF Administrative boundary
- Ward boundary
- Flooding hotspots

Ward Names
1 - College Park and Old Oak
2 - Wormholt and White City
3 - Shepherd's Bush Green
4 - Askew
5 - Ravenscourt Park
6 - Hammersmith Broadway
7 - Addison
8 - Avonmore and Brook Green
9 - Fulham Reach
10 - North End
11 - Palace Riverside
12 - Munster
13 - Fulham Broadway
14 - Town
15 - Parsons Green and Walham
16 - Sands End

NOTES
Hydraulic modelling has been undertaken using linked 2D-1D hydraulic modelling software TUFLOW-ESTRY (ver 2012). Refer to the LBHF Model Build Report (2015) for further information on model limitations. The intended purpose of this drawing is to illustrate flood depth in areas in excess of 81m2. Due to the coarse nature of the data the results should not be used to examine flooding at property level.

As part of the SWMP, 'flooding hotspots' have identified which meet 1 of the following criteria:
Areas greater than 225 square metres defined as Significant hazard rating during the 1% AEP rainfall event.
Areas greater than 81 square metres defined as Extreme hazard rating during the 1% AEP rainfall event.
Areas greater than 81 square metres defined as Significant hazard rating during the 10% AEP rainfall event.

Version	FINAL	Scale at A3:	1:21,500
Drawn	EB	Checked	MI
Approved	JR	Date	24/03/15

Project Title
LONDON BOROUGH OF HAMMERSMITH AND FULHAM UPDATED SURFACE WATER MANAGEMENT PLAN

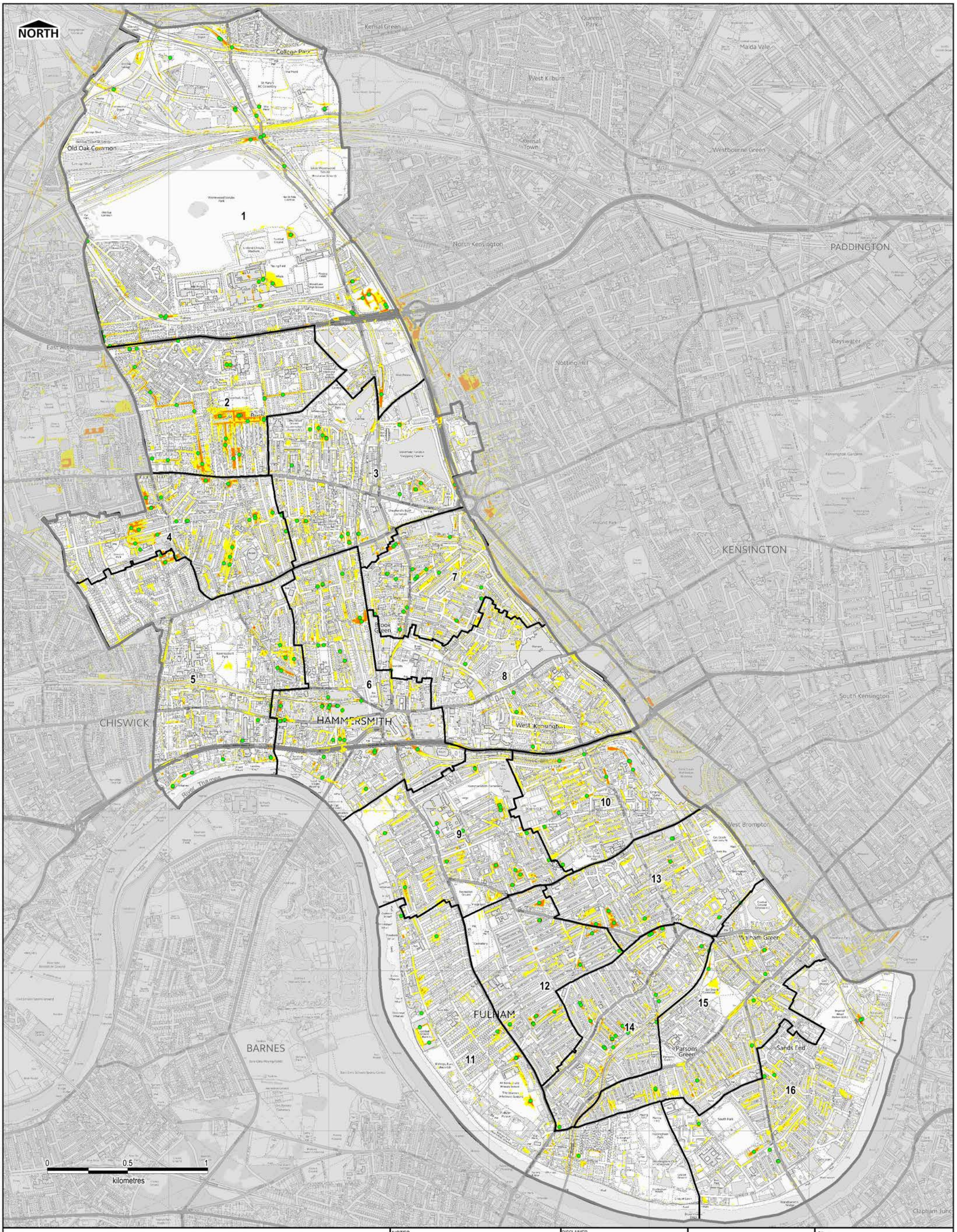
Drawing Title
MAXIMUM SURFACE WATER FLOOD DEPTH (1% AEP)

Client
h&f hammersmith & fulham

URS Infrastructure & Environment UK Ltd
6 - 8 Greencoat Place
London
SW1P 1PL
Tel. +44 (0)207 7985000
CAPITA URS Flood Risk Management

Drawing Number
FIGURE 3.4-1

Rev
04



LEGEND

Maximum Hazard Rating

- <0.75 Low Hazard (Caution)
- 0.75 - 1.25 Moderate (Danger for some)
- 1.25 - 2.0 Significant (Danger for most)
- >2.0 Extreme (Danger for all)

- LBHF Administrative boundary
- Ward boundary
- Flooding hotspots

Ward Names
1 - College Park and Old Oak
2 - Wormholt and White City
3 - Shepherd's Bush Green
4 - Askew
5 - Ravenscourt Park
6 - Hammersmith Broadway
7 - Addison
8 - Avonmore and Brook Green
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16 - Sands End

NOTES
Hydraulic modelling has been undertaken using linked 2D-1D hydraulic modelling software TUFLOW-ESTRY (ver 2012). Refer to the LBHF Model Build Report (2015) for further information on model limitations. The intended purpose of this drawing is to illustrate flood depth in areas in excess of 81m2. Due to the coarse nature of the data the results should not be used to examine flooding at property level.

As part of the SWMP, 'flooding hotspots' have identified which meet 1 of the following criteria:
Areas greater than 225 square metres defined as Significant hazard rating during the 1% AEP rainfall event.
Areas greater than 81 square metres defined as Extreme hazard rating during the 1% AEP rainfall event.
Areas greater than 81 square metres defined as Significant hazard rating during the 10% AEP rainfall event.

Version	FINAL	Scale at A3:	1:21,500
Drawn	EB	Checked	MI
Approved	JR	Date	24/03/15

Project Title
LONDON BOROUGH OF HAMMERSMITH AND FULHAM UPDATED SURFACE WATER MANAGEMENT PLAN

Drawing Title
MAXIMUM SURFACE WATER FLOOD HAZARD RATING (1% AEP)

Client
h&f hammersmith & fulham

URS Infrastructure & Environment UK Ltd
6 - 8 Greencoat Place
London
SW1P 1PL
Tel. +44 (0)207 7985000
CAPITA URS Flood Risk Management

Drawing Number
FIGURE 3.4-2

Rev
04

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Modelled Return Period	Suggested Use
1.3% AEP Figure A-10a&b	In areas where the likelihood of flooding is 1 in 75 years or greater insurers may not guarantee to provide cover to property if it is affected by flooding. This layer should be used to inform spatial planning as if property cannot be guaranteed insurance, the development may not be viable. This also corresponds to 'significant' flood risk under the FCRM GiA. For use in FDGiA applications corresponding to 'significant' flood risk. This also corresponds to Association of British Insurers threshold.
1% AEP Figure 3.4-1 & 3.4-2	Can be overlaid with the Environment Agency's Flood Zone 3 to show areas at risk of both surface water and fluvial flooding. This also corresponds to the Environment Agency's uFMfSW 1 in 100 year.
1% AEP + Climate Change Figure A-11a&b	The NPPF requires that the impact of climate change is fully assessed. Reference should be made to this flood outline by spatial planning teams to assess the sustainability of developments.
0.5% AEP Figure A-12a&b	To be used by emergency planning teams when formulating emergency evacuation plans for areas at risk of flooding. Corresponds to the FCRM GiA 'moderate' flood risk.
0.1% AEP Figure A-13a&b	This outline corresponds to the uFMfSW 1 in 1000 year.

Model Assumptions

3.4.12 As with all modelling, key assumptions are made for the LBHF he surface water modelling methodology:

- It has been assumed that land roughness varies with land type (e.g., roads, buildings, grass and water) and therefore different Manning's roughness coefficients have been specified for different land types to represent the effect
- Building thresholds have been included in the model in order to represent the influence they have on surface water flow paths. All building polygons within the model were raised by 100mm, meaning they act as barriers to flood waters in the model, up until the water depth becomes greater than 100mm where it is assumed that the building would flood and water would flow through the building, as would be the case in an actual flood event;
- The presence of a roadside kerb can be a significant influence on the movement of flood water. The vertical accuracy of the LiDAR means differences between road and pavement levels are not necessarily accurately represented. Therefore, the road features (defined by the OS MasterMap layer) have been lowered by 125mm to define this difference;
- A bespoke approach to modelling basements has been undertaken for this SWMP to reduce the overproduction of ponding within basement properties by assuming rainfall is routed from the roof area directly to the nearest gully.

Model Verification

3.4.13 Verification of the model is important to provide assurance that model results represent the history of flooding in the study area appropriately. In the absence of suitable calibration data, greater emphasis is placed on validation to provide an indication of the overall confidence in model results.

3.4.14 The rainfall/flood event of July 2007 in combination with records of flooded properties provides the best opportunity to verify the rainfall runoff model. Rainfall from this event was recorded at 15 minute intervals at the Holland Park rain gauge. Records of flooding were kept by the LBHF and Transport for London.

3.4.15 In order to verify the model, the average flood depth within a 10m radius of each record of reported flooding was determined. Where the flood depth from the modelled simulation resulted in an average depth of less than 0.1m, the point was queried to determine why flooding was not being modelled where it has historically occurred.

3.4.16 Of the 143 flood records held by LBHF Council, 120 (84%) were found to have a flood depth of 0.1m or greater during the 2007 modelled scenario. This result provides confidence in the representation of surface water flooding within the model area.

Mapping of Surface Water Flood Risk

3.4.17 The mapping shown within this report is intended to identify broad areas which are more likely to be vulnerable to surface water flooding. This allows LBHF and its partners to undertake further detailed analysis in areas which are most vulnerable to surface water flooding.

3.4.18 The mapping can be used to support spatial planning to ensure that surface water flooding is appropriately considered when allocating land for development. The mapping can be also used to assist emergency planners in preparing their Multi-Agency response plans.

Limitations

3.4.19 It should be noted that this mapping only shows the predicted likelihood of surface water flooding for defined areas. Due to the coarse nature of the source data used, the maps are not detailed enough to define risk for individual addresses. Individual properties therefore may not always face the same probability of flooding as the areas that surround them. Due to the modelling process, areas where there are steep changes in gradient, such as a railway embankment, show there to be isolated areas of deep flooding. These flood depths are a result of TUFLOW compensating for the high velocity resulting from a steep drop in topography. They should not be considered to be representative of the flood depths likely to be experienced in this area.

3.4.20 In addition, the railway and tube lines that are below ground level but are not covered are shown to have flood depths in excess of 1.0m. The nature of the railway lines does suggest a greater susceptibility to surface water flooding, however no account has been made for drainage within these areas. Therefore the degree and depth of flooding should be considered indicative only.

3.4.21 Section 3.4.12 describes that a bespoke methodology was applied to provide improved representation of basements and basement flooding. Further details of this can be found in the LBHF SWMP Model Build Report. Examination of the model results shows that this has been effective across the model extent. There remain a small number of locations where isolated areas of basements are still shown to have significant flood depths resulting from overland flow draining into the low lying area of the basement. The depths shown in these instances should be treated with caution as these may be an artefact of the errors within the LiDAR. Basements are more vulnerable to surface water flooding, and therefore where a risk is suspected, site specific analysis should be undertaken to verify risk.

3.4.22 There may also be particular occasions when flooding has occurred in the past that does not match the predicted patterns shown on these maps. The maps reflect all the suitable and relevant data provided and have been produced using expert knowledge to create conclusions that are as reliable as possible. However, it is essential that users of these maps understand the complexity of the data and modelling utilised in their production and are also aware of the associated limitations and uncertainties in the mapping. The maps are not intended to be used in isolation.

3.4.23 The Greater London Authority, LBHF and Tier 1, Tier 2 and Tier 3 Drain London Consultants cannot be held responsible for misuse or misunderstanding of the maps provided as part of the SWMP.

Depth Mapping

3.4.24 For each extreme rainfall event the maximum surface water depth grids have been extracted from the TUFLOW modelling results and thematically mapped in GIS (MapInfo) to illustrate maximum flood depth. Flood Depth Figures are included in Appendix A.

Hazard Mapping

3.4.25 Guidance set out by Defra (2005)[iii] categorises the danger to people for different combinations of flood water depth and velocity as shown in Table 3-4.

3.4.26 The flood hazard classification was calculated to Defra R&D Technical Report FD2320/TR2[iv] and the May 2008 EA/HR Wallingford supplementary guidance notev. The flood hazard rating (HR) was calculated within TUFLOW according to the following formula from these reports:

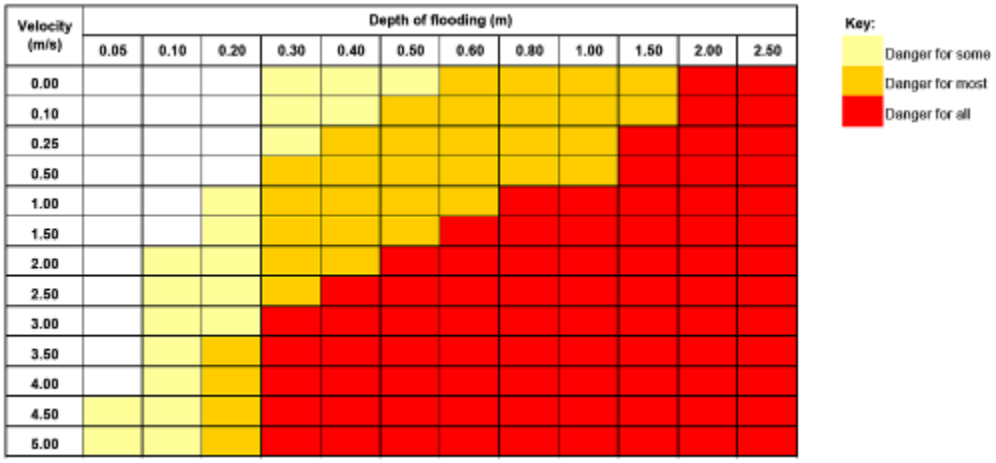
$$HR = d\,(v + 0.5) + DF$$

(d = depth of flooding, v = velocity of flooding and DF = Debris factor)

3.4.27 The debris factor was selected as described in FD2320 and its supplementary guidance note, i.e. DF = 0.5 if d≤0.25 m and DF = 1 if d>0.25 m or v>2 m/s.

[iii] Defra and Environment Agency. October 2005. '*Framework and Guidance for Assessing and Managing Flood Risk for New Development*', Flood Risk Assessment Guidance for New Development. FD2320 R&D Technical Report 2. Defra London. Table 13.1, Pg. 118.
[iv] R&D Technical Report 2 FD2320/TR2 Flood risk assessment guidance for new development – Framework, guidance and tools (2006).
[v] Supplementary note on flood hazard ratings and thresholds for development planning and control purpose (2008).

Table 3-4 Danger to people relative to flood depth and velocity (Taken from Table 13.1 of the Defra/EA FD2320/TR2 report).



3.4.28 Flood Hazard ratings in spatial data format were included in the outputs from the model. The flood hazard ratings are classified into the flood hazard categories shown in Table 3-5. These model outputs were incorporated into Flood Hazard mapping.

Table 3-5 Flood Hazard Classification from Supplementary Guidance Note

Flood Hazard Rating	Degree of Flood Hazard	Description
<0.75	Low	**Caution –** "Flood zone with shallow flowing water or deep standing water"
0.75 – 1.25	Moderate	**Dangerous for some (i.e. children) –** "Danger: Flood zone with deep or fast flowing water"
1.25 – 2.0	Significant	**Dangerous for most people –** "Danger: flood zone with deep fast flowing water"
>2.0	Extreme	**Dangerous for all –** "Extreme danger: flood zone with deep fast flowing water"

3.5 Sewer Flooding

Flooding Mechanism

3.5.1 During heavy rainfall, flooding from the sewer system may occur if:

1. The rainfall event exceeds the capacity of the sewer system / drainage system

Since the late 1970s, and with the publication of Sewers for Adoption[vi] in 1980, sewer systems have typically been designed and constructed to accommodate a rainfall event with a 1 in 30 probability of occurrence in any given year (3.3%) or less. Therefore, rainfall events with a rainfall probability of greater than 3.3% AEP would be expected to result in surcharging of

[vi] The Sewers for Adoption guide was first issued in 1980 by WRc. Since then the document has become the standard for the design and construction of sewers to adoptable standards in England and Wales. It acts as a guide to assist developers in preparing their submission to a sewerage undertaker before they enter into an Adoption Agreement under Section 104 of the Water Industry Act 1991

some of the sewer system. While Thames Water Utilities Ltd. is concerned about the frequency of extreme events, it is not economically viable to build sewers that could cope with every extreme. It is important to note that most of the sewer system in London was built prior to the 1970s, and in many cases has a capacity of far less 3.3% AEP.

2. The system becomes blocked by debris or sediment

Over time there is potential that road gullies can become blocked from fallen leaves, build-up of sediment and debris (e.g. litter).

3. The system surcharges due to high water levels in receiving watercourses

Within the Borough there is potential for sewer outfalls to rivers to become submerged during high water levels (either fluvial or tidal). When this happens, water is unable to escape into the river and flows back along the sewer. Once storage capacity within the sewer itself is exceeded, the water will overflow into streets and houses.

Responsible Organisations

3.5.2 The Highway Authority (LBHF and TfL in the case of red route) are responsible for the effectual drainage of roads insofar as ensuring that drains, including kerbs, road gullies and the pipe network which connects to the trunk sewers are maintained (Figure 3.5-1).

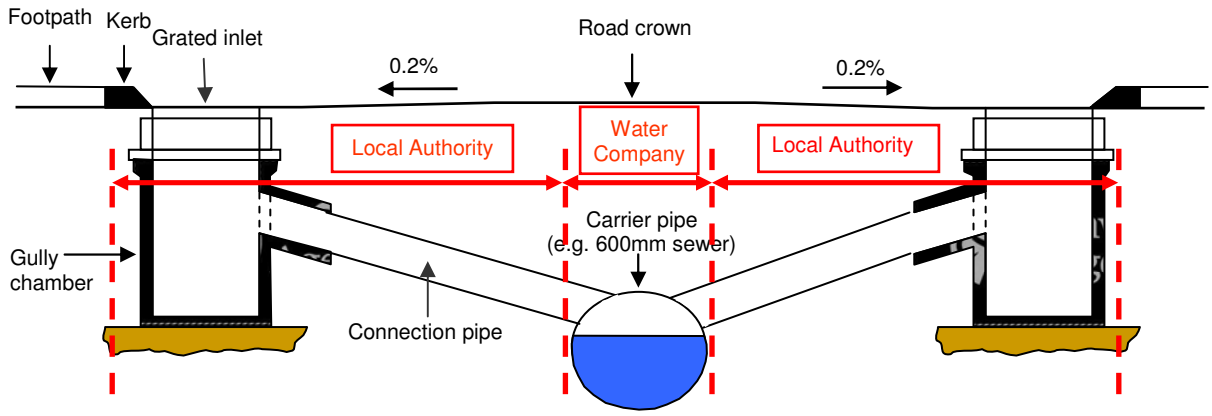


Figure 3.5-1 - Surface Water Drainage Responsibility

3.5.3 Thames Water Utilities Ltd. are responsible for surface water drainage from premises via adopted sewers and are responsible for maintaining trunk sewers into which much of LBHF's highway drainage connects.

3.5.4 In addition to the Thames Water Utilities Ltd. network, there are also some sewers and drains which are in private ownership. Most of these private systems connect to the Thames Water Utilities Ltd. public sewerage system for treatment; however private owners can also connect foul water to septic tanks and storm water to soakaways.

The Counters Creek Catchment

3.5.5 The Counters Creek is one of the 'lost rivers' of London. The catchment of this former river drains as part of the Thames Water sewer network. The catchment extends through the boroughs of Ealing, Hammersmith and Fulham, Brent, Camden, Westminster and Kensington and Chelsea. Rainfall events over the last few years have highlighted the susceptibility of this catchment to sewer flooding as a result of increased development and loss of green space. Many properties have become more vulnerable to flooding due to subterranean development that creates habitable spaces below ground and below the sewers and floodwater on the surface. Thames Water Utilities Ltd. are currently undertaking a programme of implementing anti-flood devices at properties at risk of sewer flooding, as well as implementing a longer term upgrade of the sewer network.

3.5.6 The Counters Creek drainage network has been incorporated into the SWMP model to allow for the interaction of surface water and sewer flooding to be investigated.

3.5.7 The land use management within the upstream extent of the Counters Creek catchment will influence the volumes of surface water entering the catchment during rainfall events. This will therefore affect the capacity of the network in downstream areas such as the LBHF. The LBHF should therefore use this information to co-ordinate integrated surface water and sewer management schemes across the catchment area.

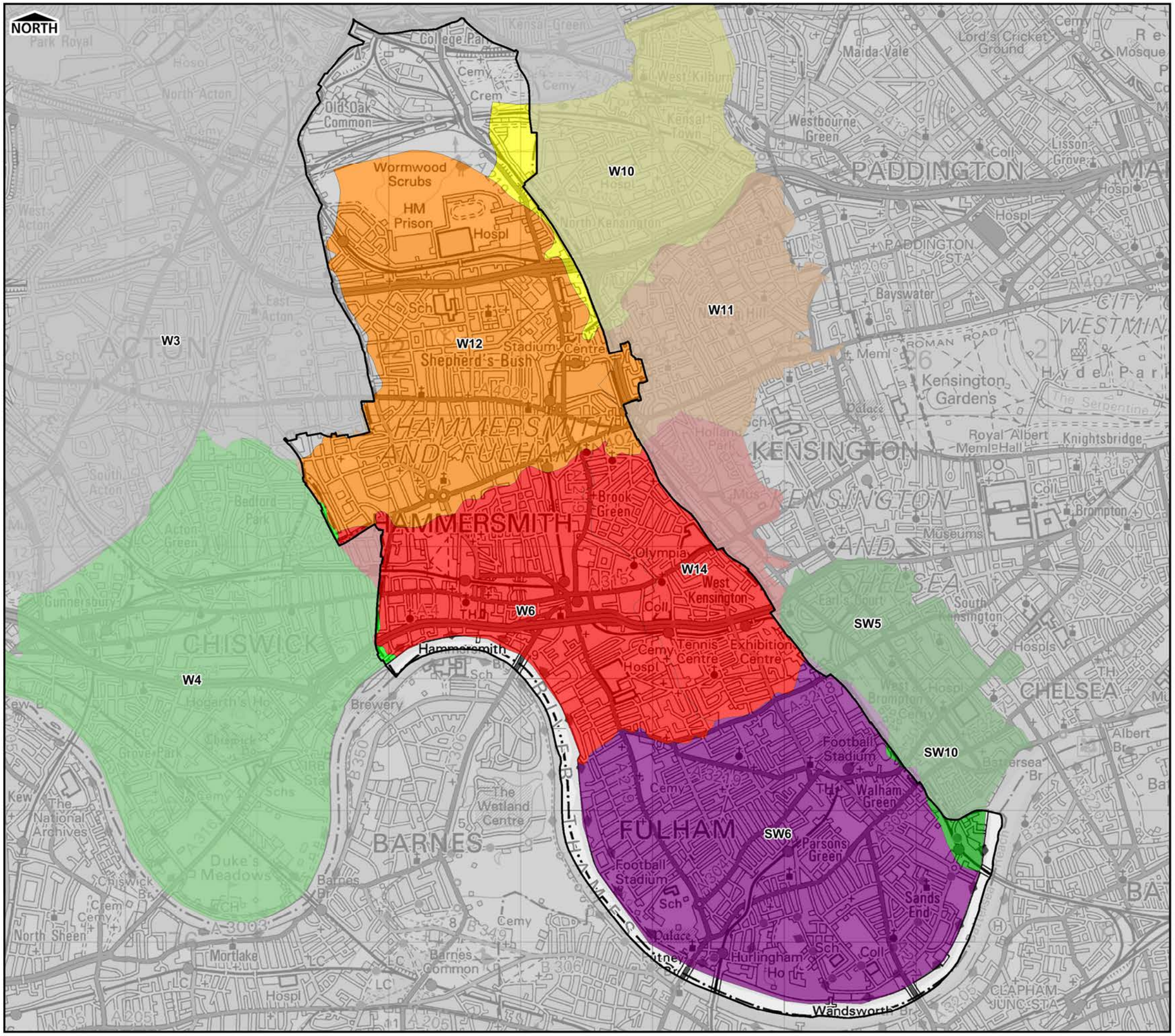
Thames Water Data: DG5 Register

3.5.8 Thames Water Utilities Ltd. has provided their DG5 database which details the total number of properties at risk of sewer flooding (both externally and internally) in June 2014. The DG5 dataset is provided on a four-digit postcode area. The number of records for each postcode district have been summed to provide area-based sewer flooding risk dataset as can be seen in Figure 3.5-2 In addition, Thames Water Utilities Ltd. focus their efforts on removing properties from the DG5 register, and therefore this dataset may no longer accurately represent those properties which are currently at risk.

3.5.9 The DG5 Register highlights a number of areas within the Borough to be at a higher risk of sewer flooding, with the following areas being particularly vulnerable (*numbers in brackets indicate number of records of sewer flooding incidents):*

- Fulham SW6 (872)
- Hammersmith W6 (415)
- Shepherd's Bush W12 (283)
- West Kensington W14 (418)
- Notting Hill W11 (310)
- North Kensington W10 (53)
- West Brompton SW10 (38)
- Earls Court SW5 (12)
- Chiswick W4 (4)
- Acton W3 (no data)

Figure 3.5-2 Thames Water Utilities Ltd. DG5 Records



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

LBHF Administrative Area

DG5 Records

- No Data
- 1 - 10
- 10 - 50
- 50 - 100
- 100 - 400
- 400 - 800
- 800+

London Borough of Hammersmith & Fulham

h&f hammersmith & fulham

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:30,000	June 2014	DS	EC

Thames Water Utilities Ltd.
DG5 Flood Records

Consultants

URS Infrastructure and Environment UK Ltd
6 - 8 Greencoat Place
London
SW1P 1PL

CAPITA | URS
Flood Risk Management

Figure 3.5-2

Version 3

Modelling the Sewer Network

3.5.10 A key component of the baseline model build undertaken for this SWMP is the incorporation of the sewer network within the model. The sewer network has been incorporated as a 1D network that is linked with the 2D above-surface model. The 1D hydraulic model was based on network geometry data provided by Thames Water Utilities Ltd. as used in their Counters Creek model. The gullies and manholes have been used to connect the 1D and 2D elements of the model. Details of gully locations were provided by the LBHF.

Model Assumptions

3.5.11 The following assumptions were made when developing the 1D component of the baseline model:

- The surface water outfalls were tide locked, limiting discharge to the River Thames which represents a worst case scenario;
- No pumping stations or Combined Sewer Overflows (CSOs) have been incorporated due to a lack of data;
- Free discharge of water at the downstream extent of the catchment (with the exception of pipes draining to the River);
- As the sewers are combined, it is assumed 12.5% of sewer capacity is foul flow;
- Assumed no blockages within the sewer network;
- No additional drainage losses have been applied to the model;
- Manhole and gully levels are based on the LiDAR elevation; and,
- Unknown pipe types assumed to be circular.

Model Verification

3.5.12 To verify the modelled surface water and sewer flooding, the Thames Water Utilities Ltd. Counters Creek model has been run for the following scenarios:

- 1 in 10 year 1.5 hour rainfall event
- 1 in 30 year 1.5 hour rainfall event
- 2007 rainfall

3.5.13 Model outputs provided by Thames Water Utilities Ltd. from the Counters Creek hydraulic model detail the flood volumes at each of the manhole nodes. As the Counters Creek modelling is solely 1D, it is not possible to plot the flood extents resulting from the manholes where they are shown to surcharge. Therefore to interpret the modelling an analysis of the spatial correlation between manholes shown to surcharge in the Counters Creek model and the SMWP model has been undertaken.

3.5.14 The Counters Creek modelling results indicate the main areas that are likely to flood from the surcharging of sewers would be Shepherd's Bush, and the southern extent of Fulham, Parsons Green and Lillie Road/ Fulham Palace Road.

3.5.15 An initial comparison of the results for the 2007 rainfall event model runs shows a reasonable correlation between surcharging manholes from the Counters Creek model and the SWMP model. The Counters Creek model suggests there would be fewer surcharging sewers within the central part of the Borough, where the SMWP model indicates there to be a high number. This potentially indicates that the flooding shown in the SWMP model and not the Counters Creek model is due to the overland surface water component of the model rather than the sewer network.

3.5.16 A visual comparison of the Thames Water Utilities Ltd. sewer flooding records against the SWMP modelling for the July 2007 event shows an agreement between the flood records for most of the area. There are however some locations, where there are records from the SWMP model (July 2007), but no corresponding Thames Water Utilities Ltd. sewer flooding records. These are namely around the areas Shepherd's Bush (north of Uxbridge Road) and the area to the north of Hammersmith Bridge. Here it can be assumed that the flooding shown in the SWMP modelling for the July 2007 event was driven by other surface water flooding mechanisms rather than sewer flooding from the Thames Water Utilities Ltd. network.

3.5.17 It should be noted that there are a number of large differences between the Thames Water Utilities Ltd. Counters Creek hydraulic model and the SWMP TUFLOW model. These include:

- The catchment area for the Counters Creek extends well beyond the LBHF administrative area. Therefore the time to peak of the design storms will differ between the models.
- As the SWMP model does not take into account the entire Counters Creek catchment, it is assumed that there are no restrictions at the downstream boundary, including not accounting for the potential backing up of water further downstream in the network.
- The function of the CSOs is not modelled in the SWMP model. Therefore water is not lost from the model at these points, providing a more conservative estimate of the sewer network capacity. The influence of this on the total flood extents will be most noticeable during the smaller return period events, as beyond this, the capacity of the sewer system to receive flows is exceeded resulting in more surface flooding in the upper catchment.
- The SWMP model potentially has pockets of surface water storage within the 2D domain resulting from depressions in the land surface that is not connected to the sewer network.

3.5.18 The Counters Creek model is likely to provide a better representation of flooding at lower magnitude rainfall events due to the explicit representation of the sewer network. The SMWP model will be a better representation of high magnitude rainfall events as the function of the sewer network in these scenarios is less influential.

Recommendation 6: Work with the Thames Water Utilities Ltd. to identify opportunities for the integrated management of surface water and sewer flooding across the Borough.

3.6 Ordinary Watercourse Flooding

3.6.1 Ordinary watercourse flooding includes flooding from small open channels and culverted urban watercourses[vii]. These small channels often receive most of their flow from inside the urban area and perform an urban drainage function.

[vii] All watercourses that are not designated Main River, and which are the responsibility of Local Authorities.

3.6.2 The Detailed River Network (DRN) has been provided by the Environment Agency and identifies that with the exception of the River Thames along the southern border, and Grand Union Canal in the north, there are no main rivers, or ordinary watercourses within LBHF (Figure 3.6-1).

3.6.3 The Stamford Brook and Counters Creek are classified as sewers and fall under the responsibility of Thames Water Utilities Ltd.

Figure 3.6-1 Environment Agency Main Rivers & Flood Map

3.7 Groundwater Flooding

Mechanism of Flooding

3.7.1 Groundwater flooding occurs as a result of water rising up from the underlying aquifer or from water flowing from springs. This tends to occur after much longer periods of sustained high rainfall, and the areas at most risk are often low-lying where the water table is likely to be at shallow depth. Groundwater flooding is known to occur in areas underlain by principal aquifers, although increasingly it is also being associated with more localised floodplain sands and gravels.

3.7.2 Groundwater flooding tends to occur sporadically in both location and time, and tends to last longer than fluvial, pluvial or sewer flooding. When groundwater flooding occurs, basements and tunnels can flood, buried services may be damaged, and storm sewers may become ineffective, exacerbating the risk of surface water flooding. The vulnerability of basements to groundwater flooding and also, the impact of discharges from basement dewatering systems on the sewer network should be considered when reviewing groundwater flooding.

3.7.3 It is also important to consider the impact of groundwater level conditions on other types of flooding e.g. fluvial, surface water and sewer. High groundwater level conditions may not lead to widespread groundwater flooding. However, they have the potential to exacerbate the risk of surface water and fluvial flooding by reducing rainfall infiltration capacity, and to increase the risk of sewer flooding through sewer / groundwater interactions.

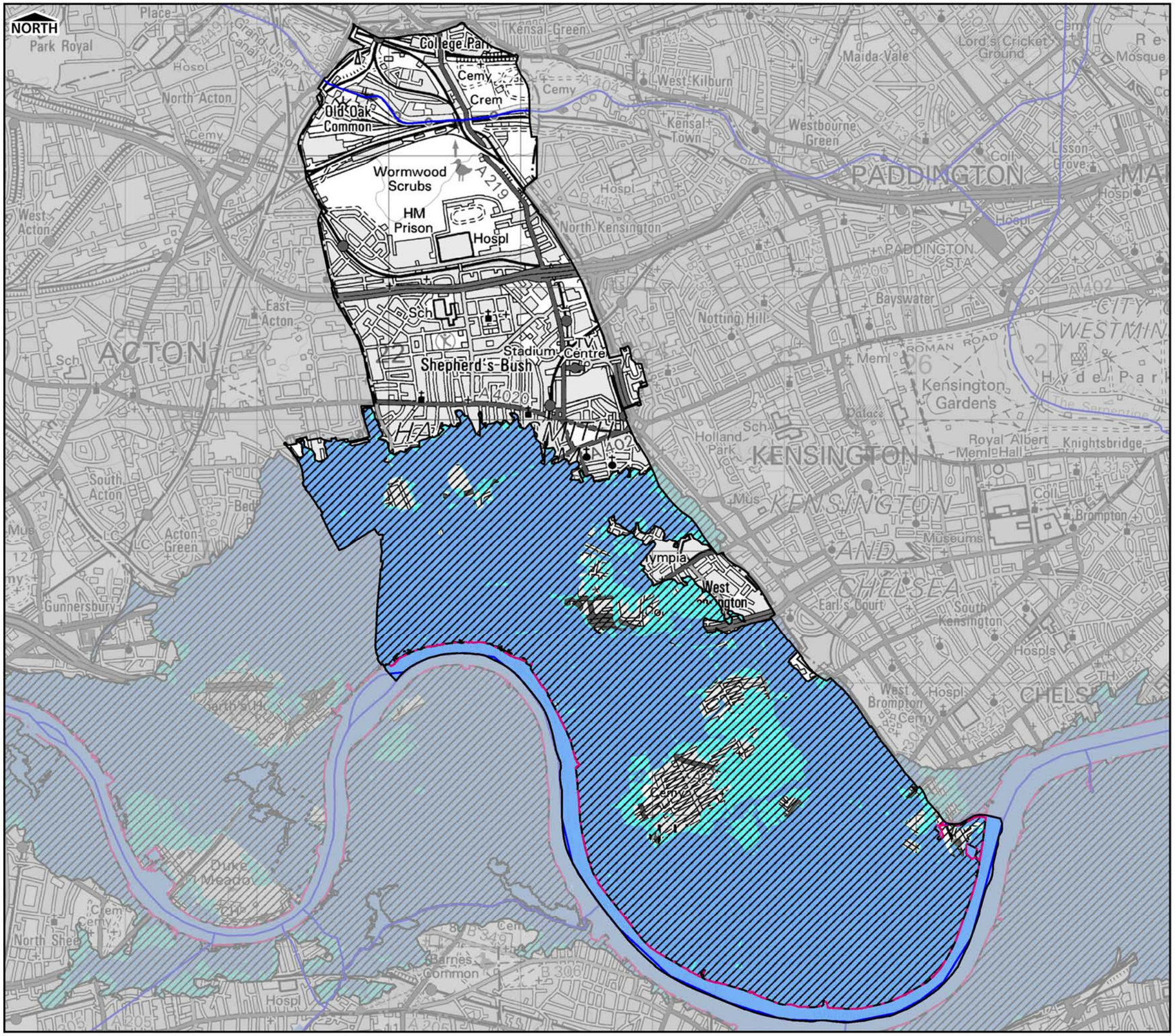
3.7.4 The need to improve the management of groundwater flood risk in the UK was identified through Defra's Making Space for Water strategy. The review of the July 2007 floods undertaken by Sir Michael Pitt highlighted that at the time no organisation had responsibility for groundwater flooding. The FWMA 2010 identified new statutory responsibilities for managing groundwater flood risk, in addition to other sources of flooding and has a significant component which addresses groundwater flooding.

3.7.5 Based on the hydrogeological conceptual understanding of the LBHF study area, the potential groundwater flooding mechanisms that may exist are provided in

3.7.6 Table 3-6.

Table 3-6 Potential Groundwater Flooding Mechanisms in LBHF

Potential Flooding Mechanism	Description
Superficial deposit aquifers along the River Thames	Groundwater flooding may be associated with the substantial sand and gravel River Terrace Deposits or to a lesser degree within Head and Alluvium deposits, where they are in hydraulic continuity with surface watercourses. River levels may rise



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Legend

- LBHF Administrative Area
- Flood Defences
- Areas Benefitting from Flood Defences
- Flood Zone 2
- Flood Zone 3
- Main Rivers / Canals

London Borough of Hammersmith & Fulham

h&f hammersmith & fulham

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:30,000	Nov 2013	DS	EC

Environment Agency Main Rivers and Flood Map

Consultants

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Flood Risk Management

URS Infrastructure and Environment UK Ltd
6 - 8 Greencoat Place
London
SW1P 1PL

Figure 3.6-1

Version 1

Potential Flooding Mechanism	Description
	following high rainfall events but still remain 'in-bank', and this can trigger a rise in groundwater levels in the associated superficial deposits. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars, which have been constructed within the superficial deposits. It is noted that modifications to the surface watercourses may limit any groundwater / surface water interactions.
Superficial deposit aquifers not in hydraulic continuity with surface watercourses (various locations)	Groundwater flooding may be associated with substantial River Terrace Deposits and Head deposits, but occurs where they are not hydraulically connected to surface watercourses. Perched groundwater tables can exist within these deposits, developed through a combination of natural rainfall recharge and artificial recharge e.g. leaking water mains. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars.
Impermeable (silt and clay) areas downslope of aquifer outcrops (various locations)	Groundwater flooding may occur where groundwater springs / seepages form minor flows and ponding over impermeable strata where there is poor drainage. This mechanism may occur as a result of natural (e.g. rainfall) or artificial (e.g. water main leakage) recharge.
Artificial ground in various locations	Groundwater flooding may occur where the ground has been artificially modified to a significant degree. If this artificial ground is of substantial thickness and permeability, then a shallow perched water table may exist. This could potentially result in groundwater flooding at properties with basements, or may equally be considered a drainage issue.

Increased Potential for Elevated Groundwater (iPEG)

3.7.7 Areas where there is increased potential for groundwater levels (iPEG areas) to rise within 2m of ground surface, following periods of higher than average recharge, are shown in Figure 3.7.1. These are separated into permeable superficial deposits and bedrock (consolidated) aquifers. The data set was produced for the whole of the Drain London project area, derived from four individual data sources:

- British Geological Survey (BGS) Groundwater Flood Susceptibility Map;
- Environment Agency / Jacobs Thames Estuary, 2100 groundwater hazard maps;
- Jacobs Groundwater Emergence Maps; and
- JBA Groundwater Flood Map.

3.7.8 It should be noted that for the majority of the Drain London study area, the BGS data set is key, as it includes an assessment of permeable superficial deposits in addition to bedrock (consolidated) aquifers. Owing to the presence of the London Clay Formation aquiclude across the majority of the Drain London study area, the main groundwater flooding mechanisms are associated with perched groundwater tables within permeable superficial deposits.

3.7.9 Figure 3.7-1 shows that within Borough there is no increased potential for elevated groundwater within the bedrock (consolidated aquifers). With respect to permeable superficial deposits, there is increased potential for elevated groundwater in the central and south-eastern areas of the Borough.

Figure 3.7-1 – Increased Potential for Elevated Groundwater Map

Climate Change and Groundwater Flooding

3.7.10 Susceptibility to groundwater flooding in LBHF may change as a result of climate change, or changes to water management. One of the climate change predictions includes the increase in rainfall during the winter months. This could lead to further groundwater flooding in the study area due to increased perched groundwater levels. It is also noted that a shift in drainage policy, with increased infiltration SuDS, may also lead to increased localised incidents of groundwater flooding, where small perched superficial deposit aquifers, with limited storage capacity, are sensitive to increased recharge.

Recommendation 7: Work with the Environment Agency to record and investigate groundwater flooding incidents and mechanisms.

3.8 Ward Assessments

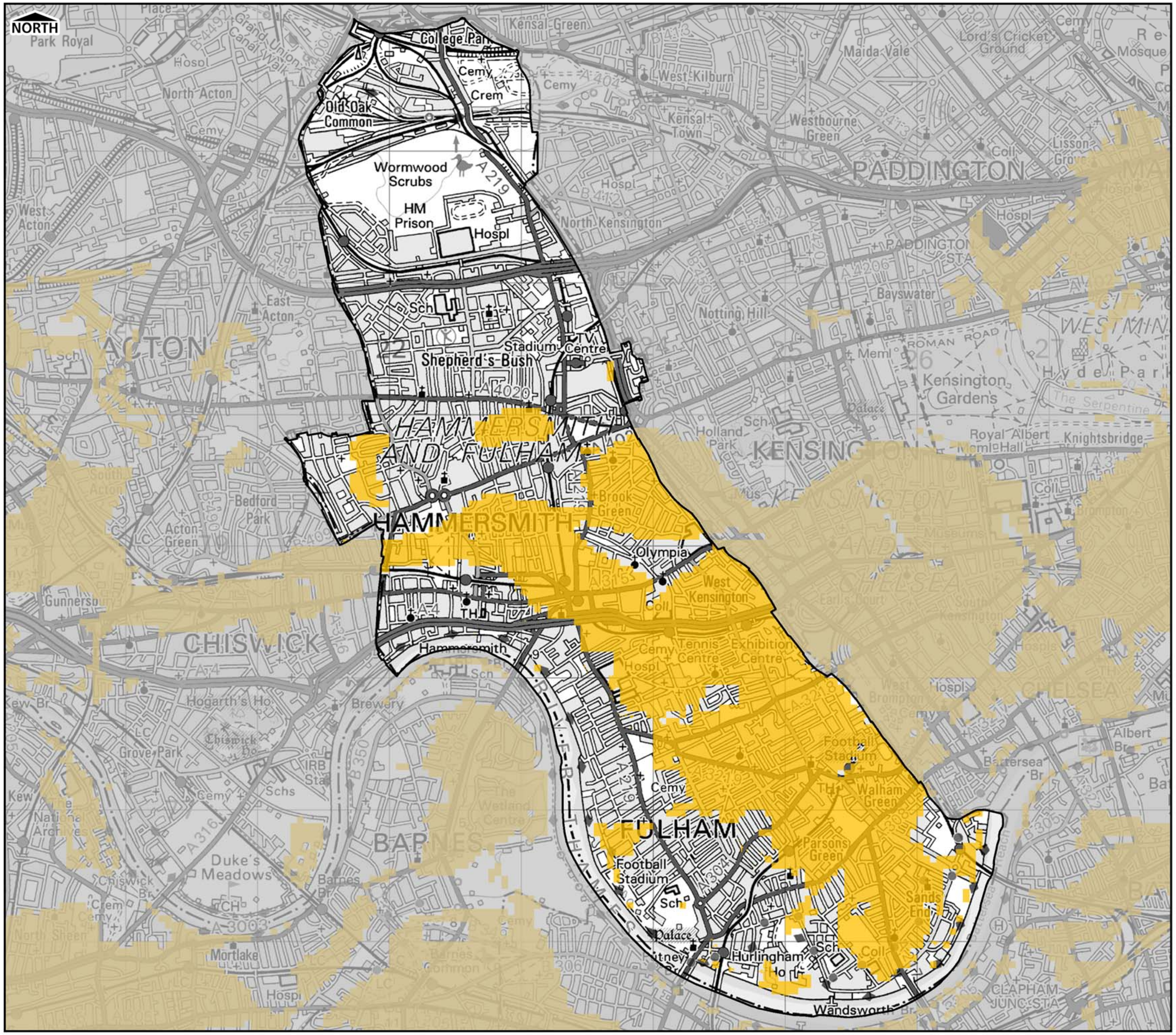
3.8.1 The remainder of this Section provides a description of each Ward including details of the surface water modelling results, verification with any records of flooding in the area, the risk of flooding from fluvial sources and susceptibility to groundwater flooding.

Property Counts

3.8.2 In order to provide a quantitative indication of potential risks, property counts have been undertaken. These utilised the Environment Agency National Receptor Dataset (NRD) and follows the methodology defined in the Drain London Data and Modelling Framework. The property counts have been undertaken to determine the number of properties flooded by an average depth of 0.1m or greater and 0.5m or greater during the 1% AEP rainfall event.

Mapping Outputs

3.8.3 Figure 3.8-1 to Figure 3.8-32 show the modelling results for each Ward; two maps for each Ward have been included which show the maximum surface water flood depth and hazard rating (and general flow direction) during the 1% AEP rainfall event.



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Legend

LBHF Administrative Area

Increased Potential for Elevated Groundwater in

Permeable Superficial Deposits

Consolidated Aquifers

DISCLAIMER

London Borough of Hammersmith & Fulham

hammersmith & fulham

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:30,000	Nov 2013	DS	EC

Increased Potential Elevated Groundwater

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Figure 3.7-1

Version 1

Ward Area 1: College Park and Old Oak

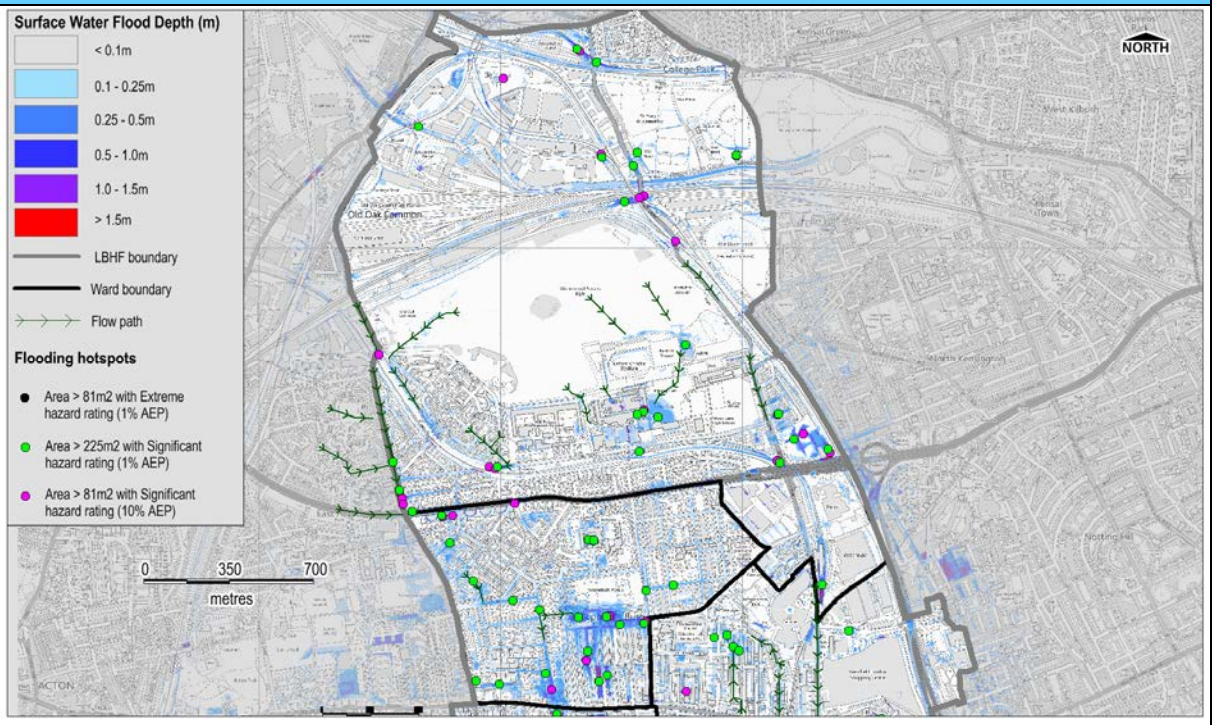


Figure 3.8-1 College Park and Old Oak 1% AEP maximum modelled flood depth

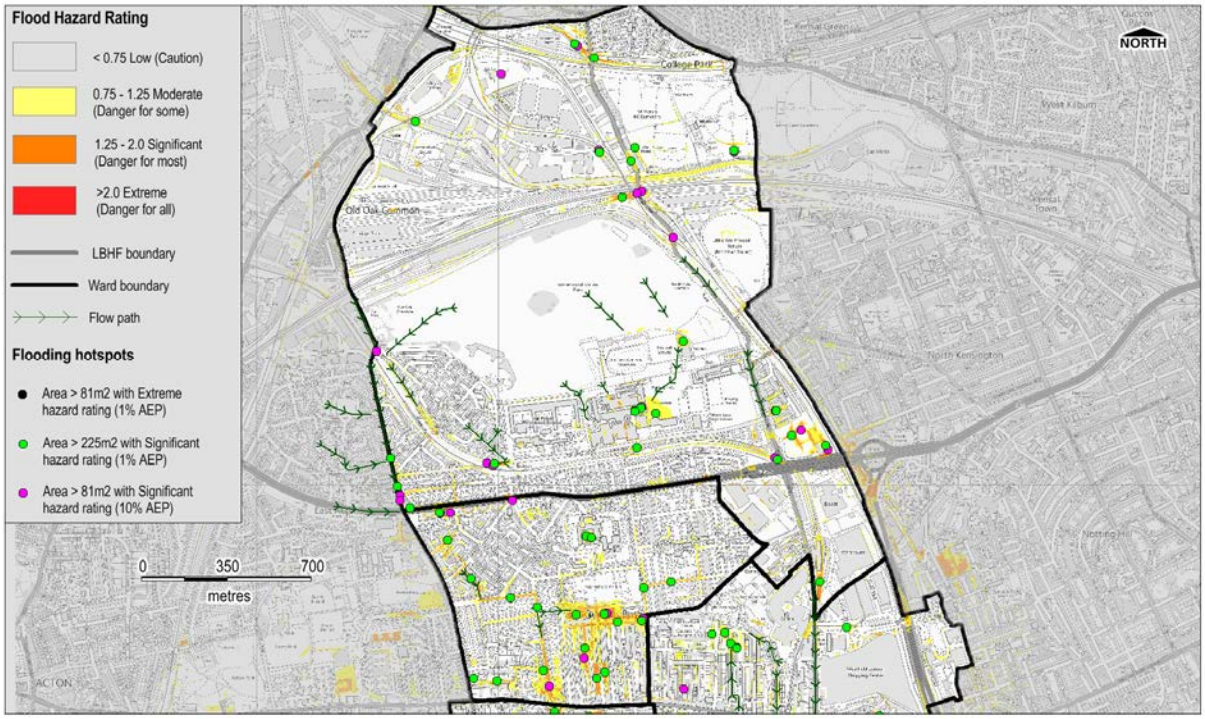


Figure 3.8-2 College Park and Old Oak 1% AEP maximum modelled flood hazard

Ward Area 1: College Park and Old Oak	
Flood Risk Categorisation	Surface water and sewer flooding.
Surface Water	The modelling shows that surface water flows from the sloped areas of Wormwood Scrubs Park and Old Oak Common towards the railway embankment to the south. The presence of buildings and the railway line causes surface water to pond in the low lying areas behind the embankment. There is the potential for surcharging of the sewer network at points along Wulfstan Street that would increase surface water flooding along the railway line. The main hazards within the Ward are associated within the areas of deep flooding and where there are high velocities, i.e. the main flow paths along the railway line.
Flooding Hotspots	There are 39 **flooding hotspots** within the Ward.
Validation	There were no Council records of surface water flooding in the Ward during the July 2007 flood event. There are 15 records of flooding recorded on the A40 from TfL records. The southern part of the Ward is located in postcode area W12 in which there are 100-400 properties on the DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 77 Residential Properties • 1 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 2 More Vulnerable Infrastructure • 0 Other Infrastructure • 16 Commercial / Industrial • 51 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 2 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 2 Commercial / Industrial 9 Unclassified
Fluvial and Tidal	Located in Flood Zone 1 Low Probability, <0.1% chance of flooding from rivers and sea.
Groundwater	The Ward is not located within an area of increased Potential for Elevated Groundwater (iPEG).

Ward Area 2: Wormholt and White City

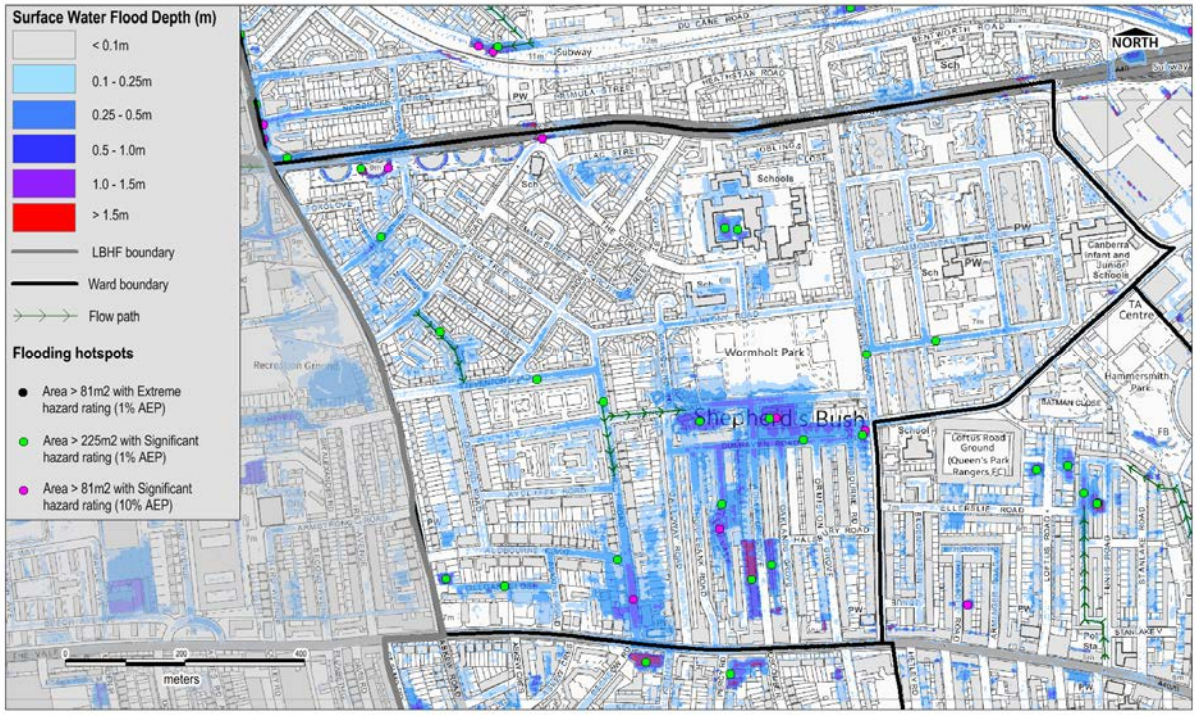


Figure 3.8-3 Wormholt and White City 1% AEP maximum modelled flood depth

Figure 3.8-4 Wormholt and White City 1% AEP maximum modelled flood hazard

Ward Area 2: Wormholt and White City	
Flood Risk Categorisation	Surface water and sewer flooding.
Surface Water	Surface water within the Ward flows in a general south easterly direction towards Shepherds Bush. There are areas of notable surface water ponding throughout the Ward, particularly Dunraven Road, Adelaide Grove, Willow Vale and Wormholt Road to the south of Wormholt Park. In addition, surface water is shown to pond in the north west part of the Ward, including Wallflower St, Steventon Road and Hillary Road.
Flooding Hotspots	There are 26 **flooding hotspots** within the Ward.
Validation	There were 6 Council records of surface water flooding in the Ward during the July 2007 flood event, and 4 records of flooding reported by TfL. There is good correlation between historic records of flooding and the surface water modelling, e.g. Wormholt Road, Bloemfontein Road and Hilary Road. The Ward is located in postcode area W12 in which there are 100-400 properties on the DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 397 Residential Properties • 1 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 5 Commercial / Industrial • 14 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 74 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 0 Commercial / Industrial • 0 Unclassified
Fluvial and Tidal	Located in Flood Zone 1 Low Probability, <0.1% chance of flooding from rivers and sea.
Groundwater	The Ward is not located within an area of increased Potential for Elevated Groundwater (iPEG).

Ward Area 3: Shepherd's Bush Green

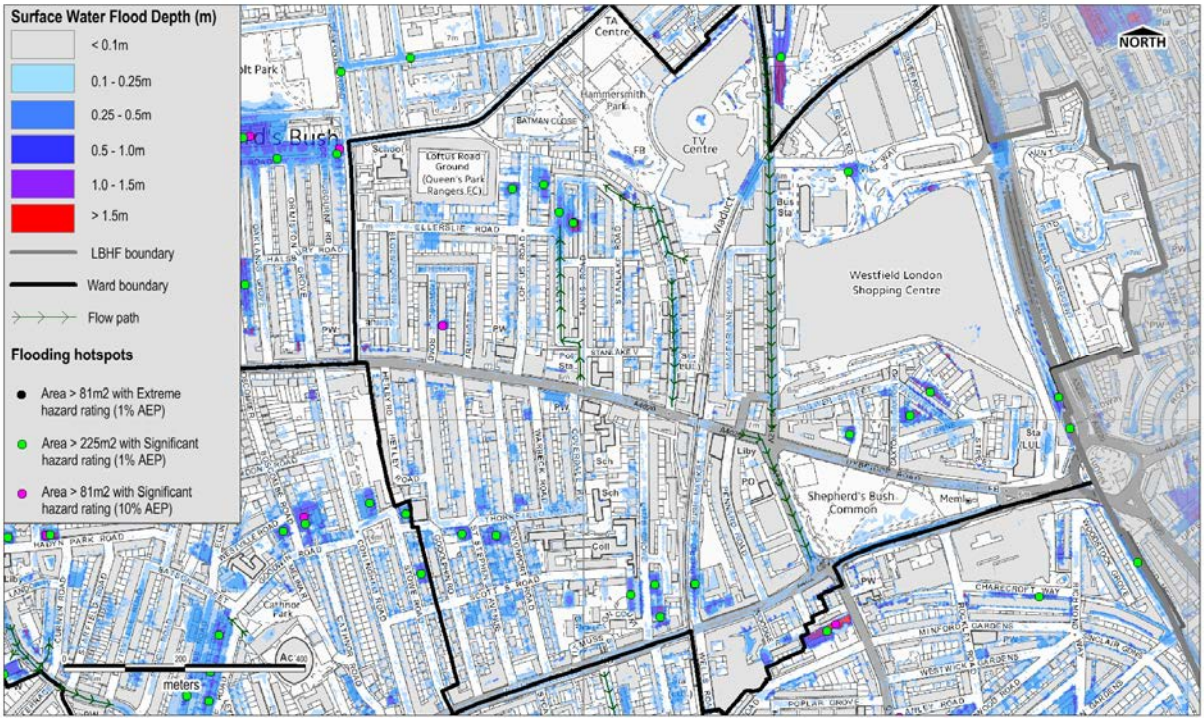


Figure 3.8-5 Shepherd's Bush Green 1% AEP maximum modelled flood depth

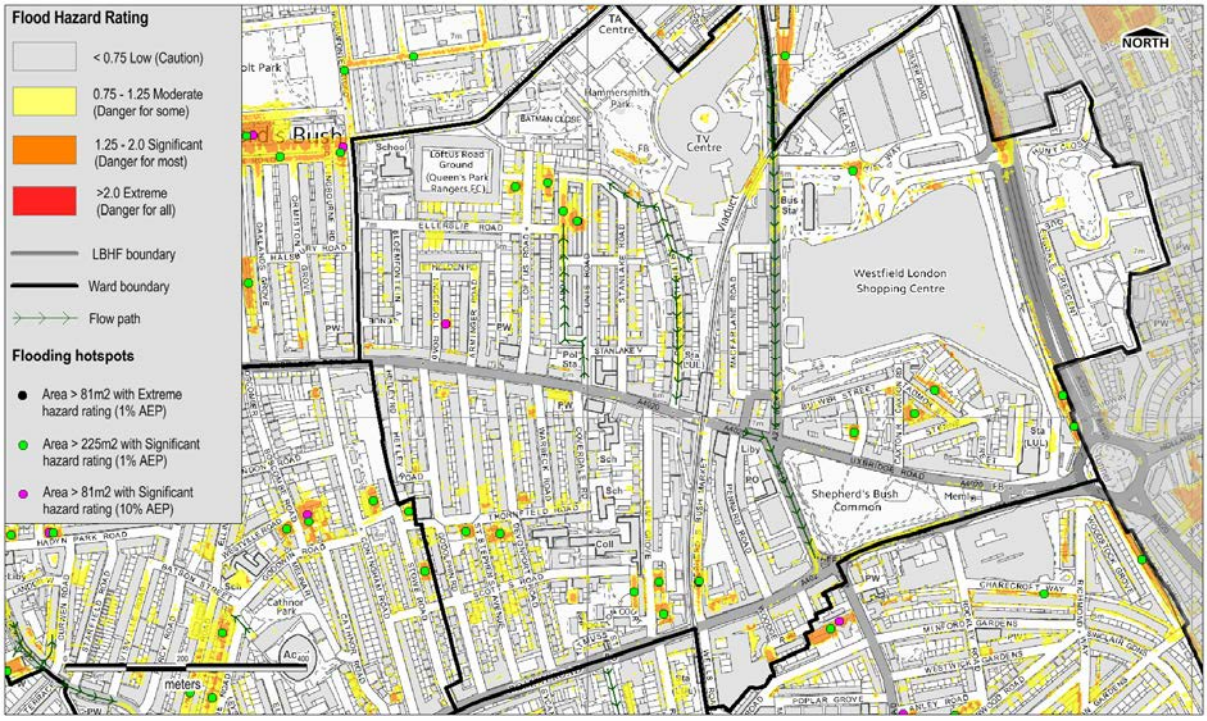


Figure 3.8-6 Shepherd's Bush Green 1% AEP maximum modelled flood hazard

Ward Area 3: Shepherd's Bush Green	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	The modelling results identify general flow paths to run north to south following the lines of the infrastructure including roads and LUL railway line. Surface water is shown to pond in the north of the Ward along Abdale Road and Loftus Road. Surface water is also shown to pond in the south west of the Ward, on Lime Grove, Shepherds Bush Market, Devonport Road, St Stephens Ave, and on roads in the south east of the Ward e.g. Tadmor St.
Flooding Hotspots	There are 19 **flooding hotspots** within the Ward.
Validation	There were 10 Council records of flooding in the Ward during the July 2007 flood event including records on Loftus Road, Stanlake Road and Uxbridge Road. The Ward is located in postcode area W12 in which there are 100-400 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 397 Residential Properties • 1 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 5 Commercial / Industrial • 14 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 74 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 0 Commercial / Industrial • 0 Unclassified
Fluvial and Tidal	The south west corner of the Ward is defined as Defended Flood Zone 3a High Probability of Flooding. Due to the presence of the Thames Tidal Defences this is a residual risk.
Groundwater	A small area of the Ward, south of the A4020, is identified as an area of increased Potential for Elevated Groundwater (iPEG).

Ward Area 4: Askew

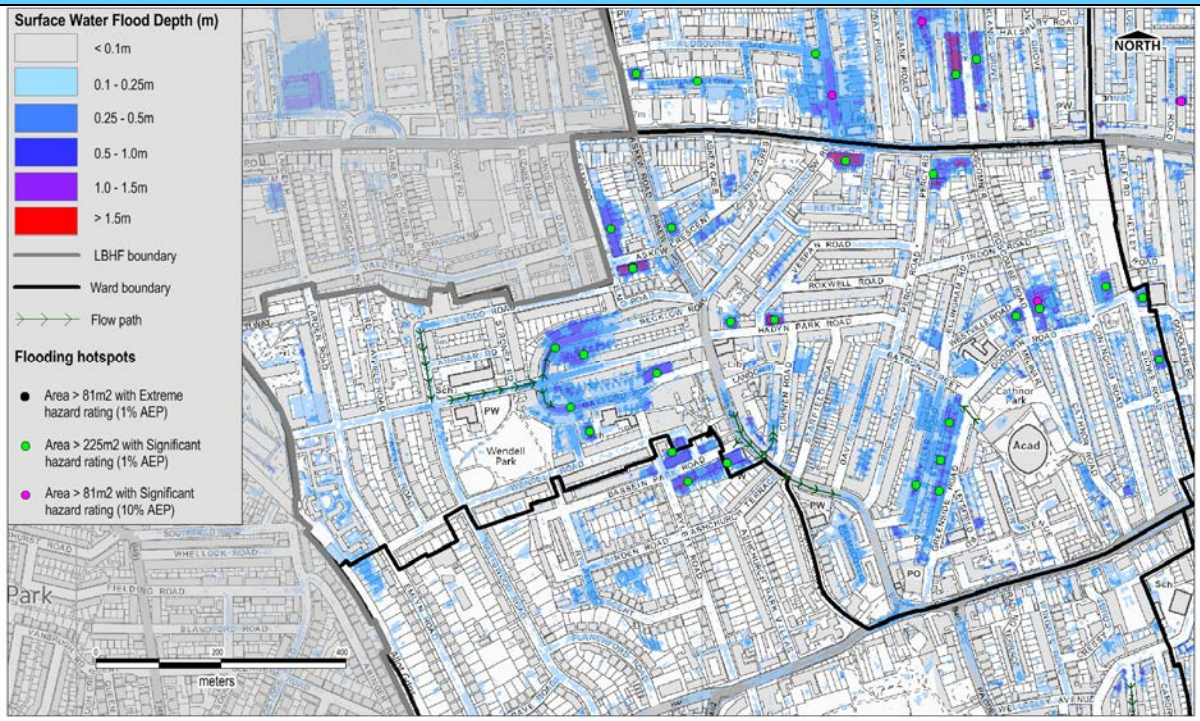


Figure 3.8-7 Askew 1% AEP maximum modelled flood depth

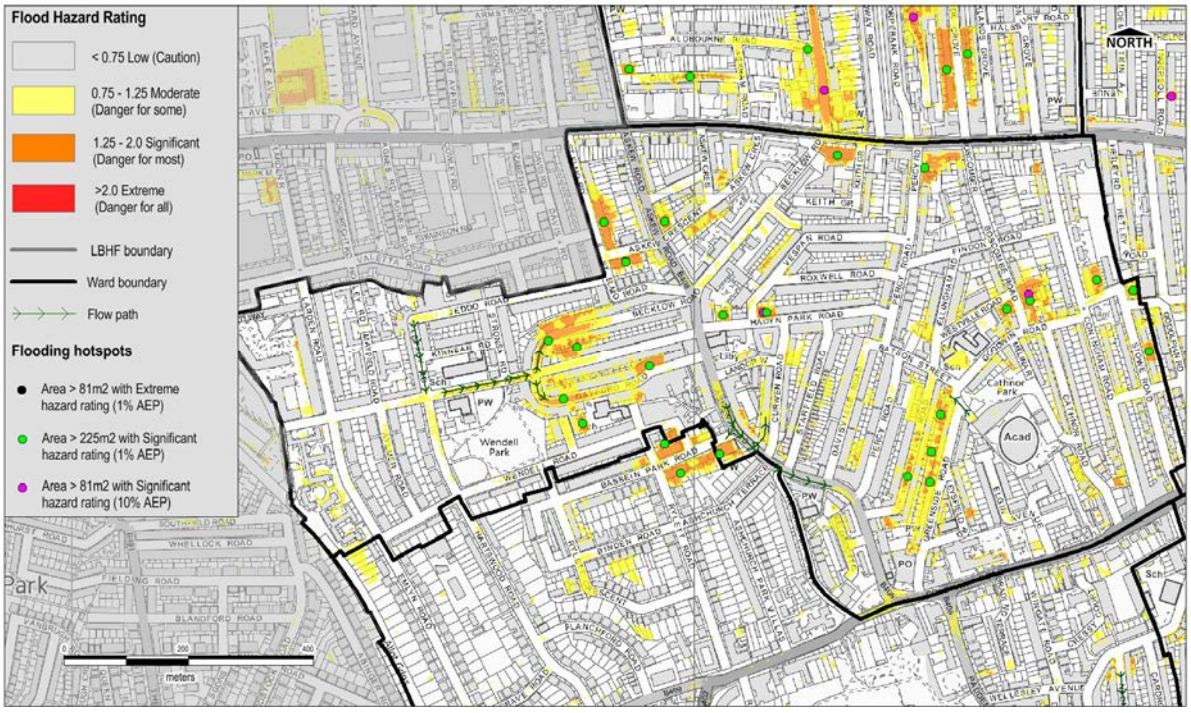


Figure 3.8-8 Askew 1% AEP maximum modelled flood hazard

Ward Area 4: Askew	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	The main flow routes originate from surcharging manholes and include Lefroy Road and Cobbold Road in the west of the Ward and Askew Road in the centre of the Ward. The surface water modelling indicates extensive flooding to the east of Cobbold Road and the adjacent roads of Becklow Road and Gayford Road. Surface water originates from the land to the north west, with some contribution from sewer flooding. Surface water flows are mainly from the north along Askew Road. The surface water modelling indicates a large extent of flooding across Westville Road. The main flow originates from Askew Road.
Flooding Hotspots	There are 25 **flooding hotspots** within the Ward.
Validation	There were 20 Council records of flooding in the Ward during the July 2007 flood event. Records are clustered along Askew Road; Cobbald Road and Grayford Road; Leysfield Road and Westville Road; Hadyn Park Road and Goodwin Road. The Ward is located in the wider postcode area W12 in which there are 100-400 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 763 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 2 More Vulnerable Infrastructure • 1 Other Infrastructure • 20 Commercial / Industrial • 29 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 120 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 1 More Vulnerable Infrastructure • 1 Other Infrastructure • 0 Commercial / Industrial • 5 Unclassified
Fluvial and Tidal	The southern part of the Ward is defined as Flood Zone 3a High Probability of Flooding from rivers and the sea. Due to the presence of the Thames Tidal Defences this is a residual risk.
Groundwater	The area to west of Askew road (B408) is identified as an area with (increased Potential for Elevated Groundwater (iPEG).

Ward Area 5: Ravenscourt Park

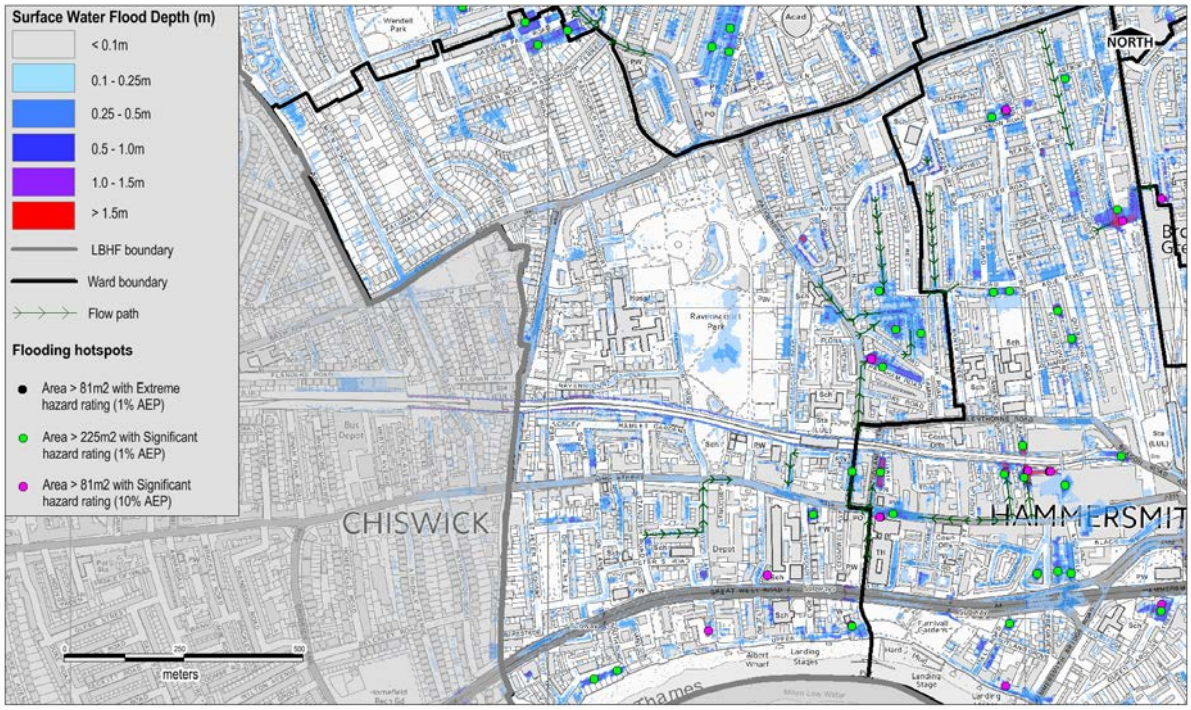


Figure 3.8-9 Ravenscourt Park 1% AEP maximum modelled flood depth

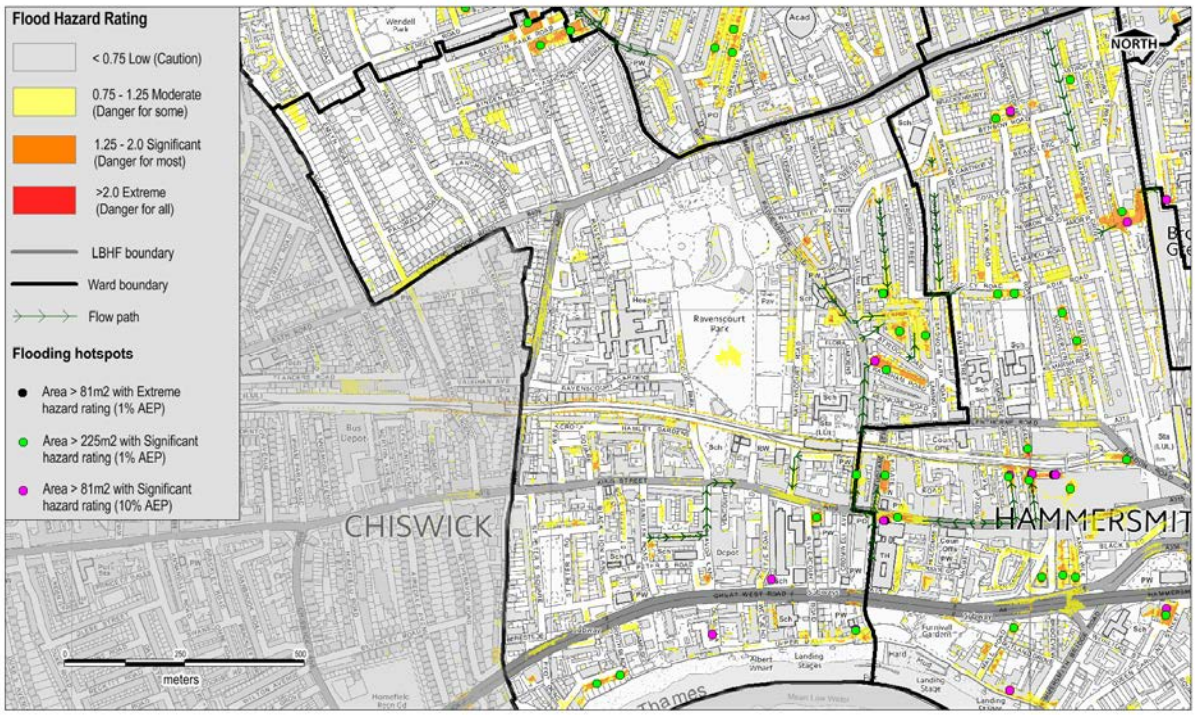


Figure 3.8-10 Ravenscourt Park 1% AEP maximum modelled flood hazard

Ward Area 5: Ravenscourt Park	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	The modelling identifies the potential for significant flood depths to accumulate in the properties adjacent to the Bassein Park Road in the north of the Ward. The modelling results also show a large extent of surface water flooding around Perrers Road in the north east of the Ward. In the south of the Ward there is potential for surface water ponding on Chiswick Mall and Upper Mall adjacent to the River Thames frontage.
Flooding Hotspots	There are 18 **flooding hotspots** within the Ward.
Validation	There were 3 Council records of surface water flooding in the Ward during the July 2007 flood event in Ravenscourt Park, Atwood Road and Standish Road. There are 3 records of flooding reported by TfL on the A4. The Ward is located in postcode area W6 in which there are 400-800 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 416 Residential Properties • 0 Essential Infrastructure • 2 Highly Vulnerable Infrastructure • 1 More Vulnerable Infrastructure • 2 Other Infrastructure • 12 Commercial / Industrial • 32 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 70 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 1 Other Infrastructure • 0 Commercial / Industrial • 8 Unclassified
Fluvial and Tidal	The Ward is within Flood Zone 3a High Probability of Flooding from rivers and the sea. Due to the presence of the Thames Tidal Defences this is a residual risk.
Groundwater	A band with increased Potential for Elevated Groundwater (iPEG) runs across the centre of Ward, across Ravenscourt Park.

Ward Area 6: Hammersmith Broadway

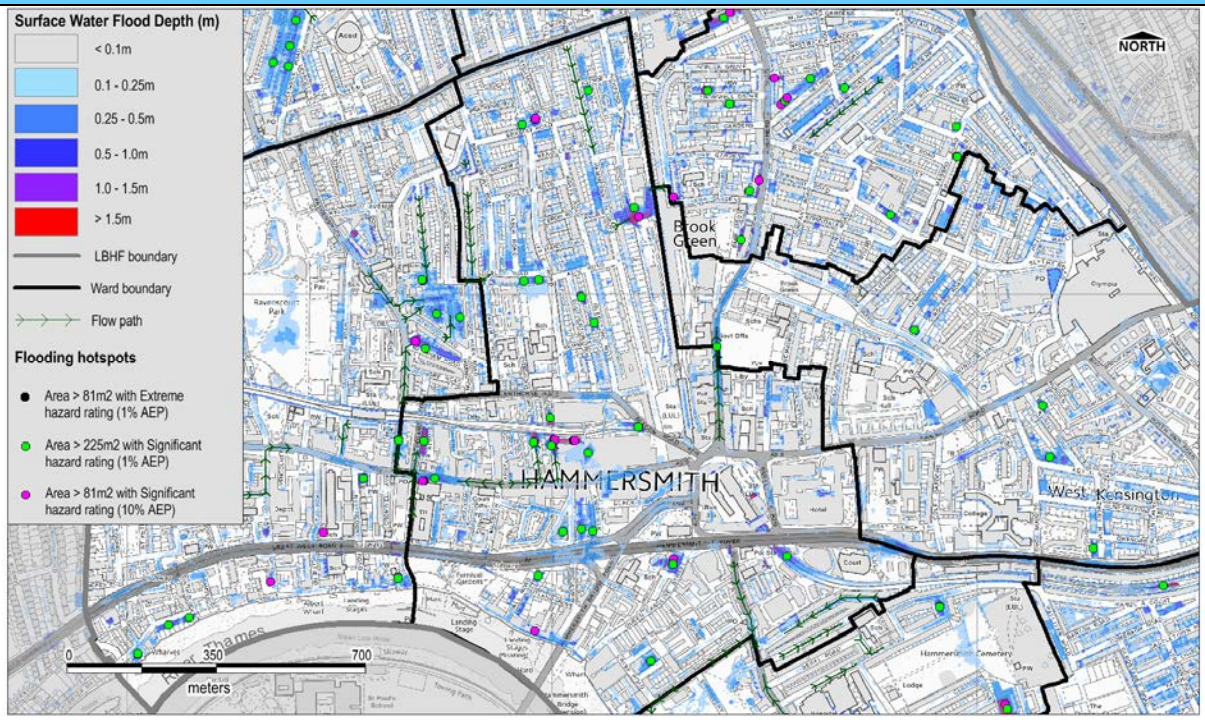


Figure 3.8-11 Hammersmith Broadway 1% AEP maximum modelled flood depth

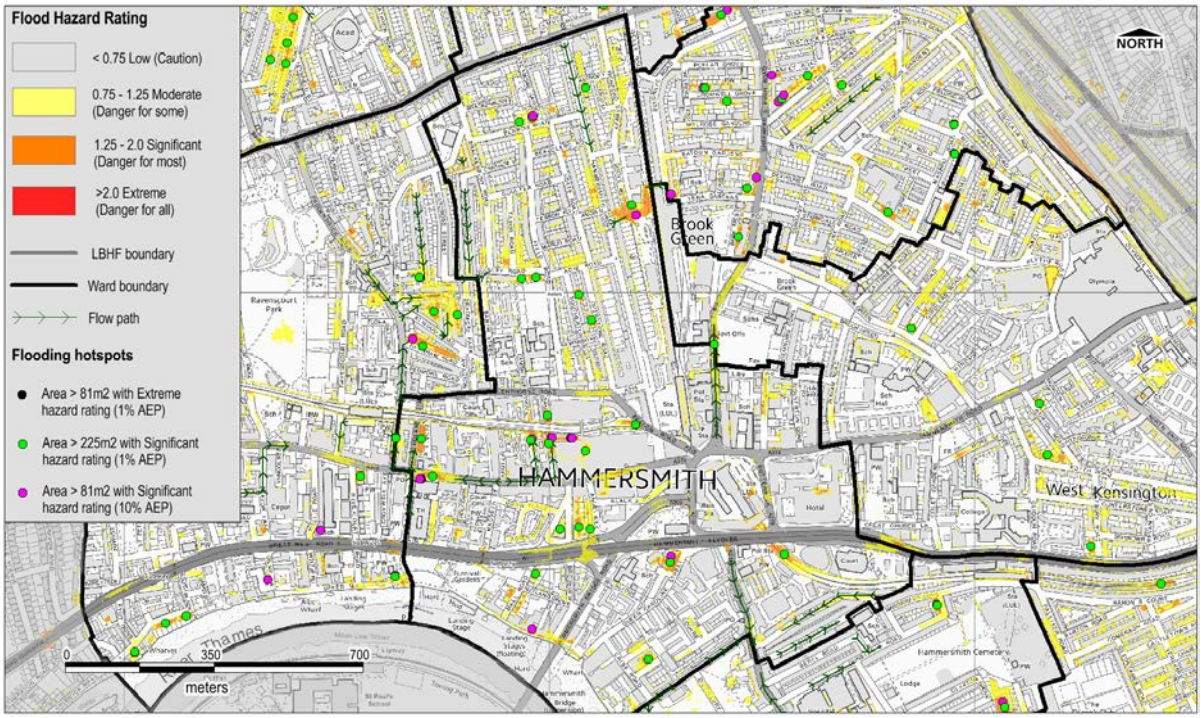


Figure 3.8-12 Hammersmith Broadway 1% AEP maximum modelled flood hazard

Ward Area 6: Hammersmith Broadway	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	The surface water modelling indicates the potential for deep flooding on Tussley Road, adjacent to the LUL railway line, north of Hammersmith Station. The main flow paths are from the north and north-west. Flooding is also modelled to occur on Hammersmith Grove and Grove Mews. In the west of the Ward, surface water is shown to pond adjacent to Aldensley Road and Tabor Road. The main flow paths originate in the west and flow along Aldensley Road, and from the north flowing along Carthew Road. In the south of the Ward, surface water modelling indicates a tendency for surface water flooding along King Street (A315) and at the underpass of the LUL railway line. Predominant flow paths to this area are from the A315 to the south.
Flooding Hotspots	There are 34 **flooding hotspots** within the Ward.
Validation	There were 28 Council records of flooding in this area during the July 2007 flood event. Records correlate well with the predicted flooding along King Street, Tabor Road, Overstone Road and Southerton Road, Hammersmith Grove and Grove Mews. There are 6 records of flooding reported by TfL on the A4. The Ward is located in postcode area W6 in which there are 400-800 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 718 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 2 More Vulnerable Infrastructure • 0 Other Infrastructure • 30 Commercial / Industrial • 33 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 101 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 1 Commercial / Industrial • 1 Unclassified
Fluvial and Tidal	The Ward is within Flood Zone 3a High Probability of Flooding from rivers and the sea. Due to the presence of the Thames Tidal Defences this is a residual risk.
Groundwater	A band with increased Potential for Elevated Groundwater (iPEG) runs across the centre of Ward, covering the area of Hammersmith underground station, bus station and road junction.

Ward Area 7: Addison

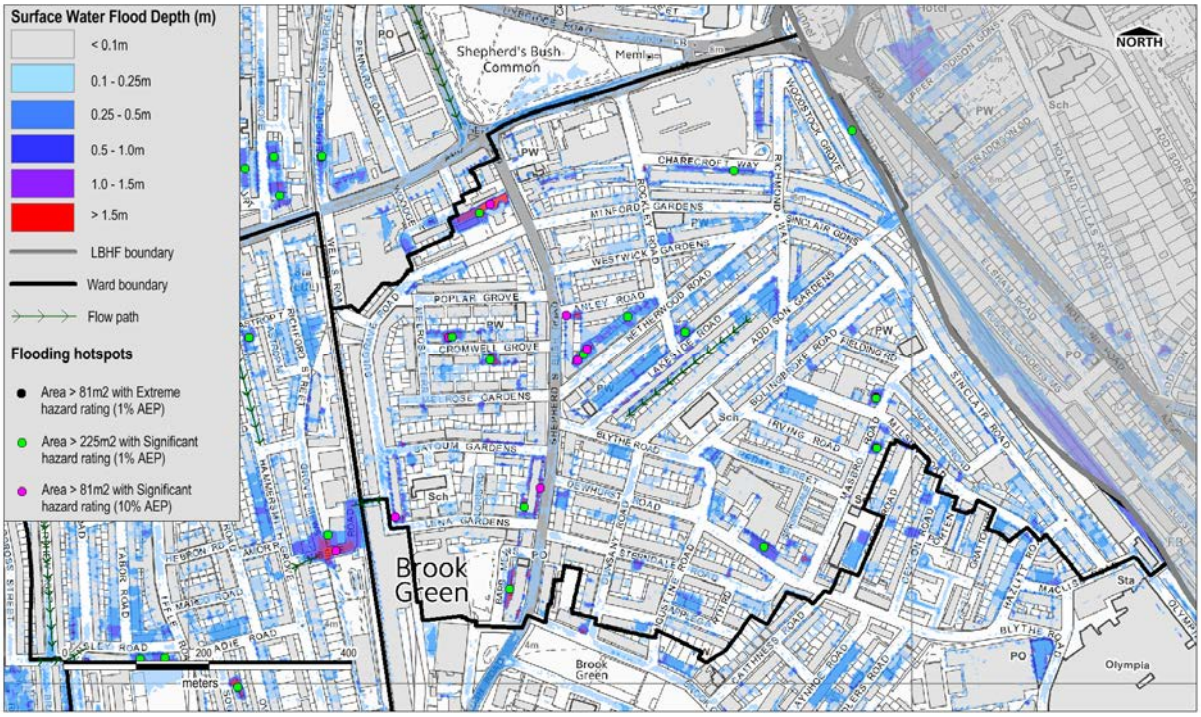


Figure 3.8-13 Addison 1% AEP maximum modelled flood depth

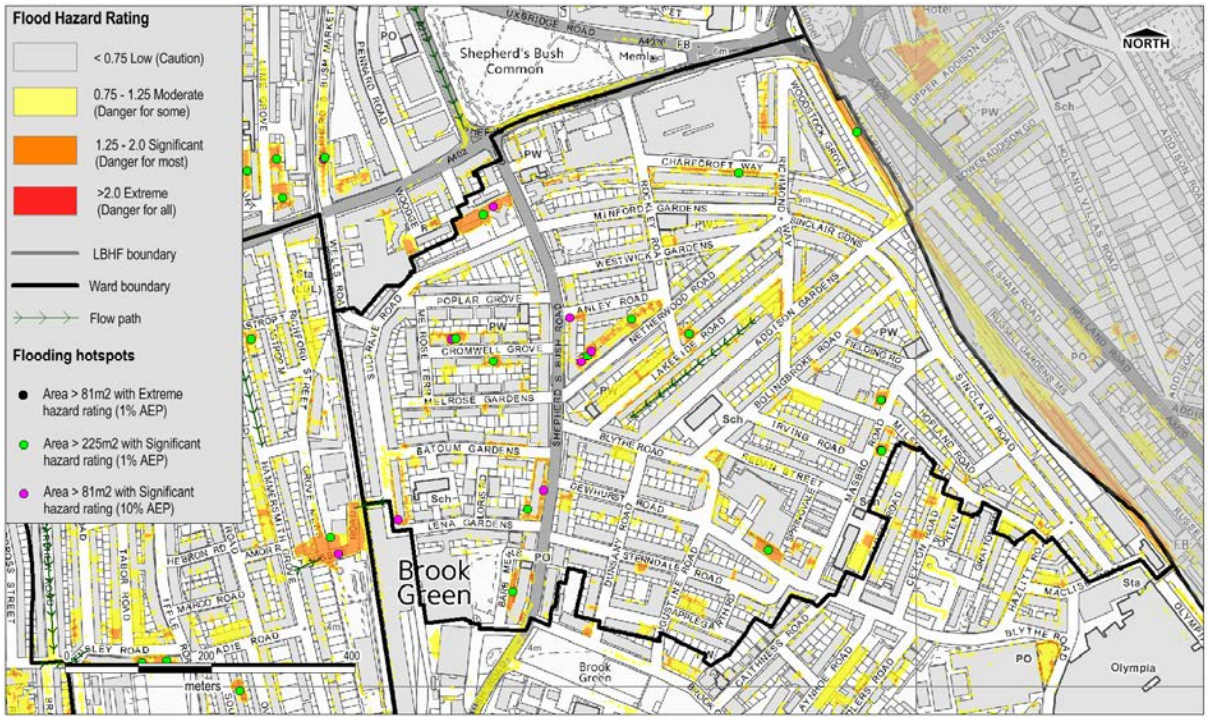


Figure 3.8-14 Addison 1% AEP maximum modelled flood hazard

Ward Area 7: Addison	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	The modelling indicates susceptibility for surface water flooding along Netherwood Road and Lakeside Road in the centre of the Ward. In addition, areas adjacent to Barb Mews and Shepherd's Bush Road are shown to experience flooding of up to 0.5m. Along the eastern edge of the Ward, surface water is shown to pond adjacent to the LUL railway line. Deep flooding is modelled to occur in the north of the Ward adjacent to the A219.
Flooding Hotspots	There are 22 **flooding hotspots** within the Ward.
Validation	There were 12 Council records of flooding in the Ward during the July 2007 flood event including Lena Gardens, Shepherd's Bush Road, Addison Gardens and Lakeside Road. There are also records along Woodstock Grove and Richmond Way in the north. There is 1 record of flooding reported for TfL on the A4. The Ward is located in postcode area W14 in which there are 400-800 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 671 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 2 More Vulnerable Infrastructure • 1 Other Infrastructure • 44 Commercial / Industrial • 23 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 70 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 5 Commercial / Industrial • 5 Unclassified
Fluvial and Tidal	The southern part of the Ward is defined as Defended Flood Zone 3a. Due to the presence of the Thames Tidal Defences this is a residual risk.
Groundwater	The majority of the Ward is defined as an area with increased Potential for Elevated Groundwater (iPEG).

Ward Area 8: Avonmore and Brook Green

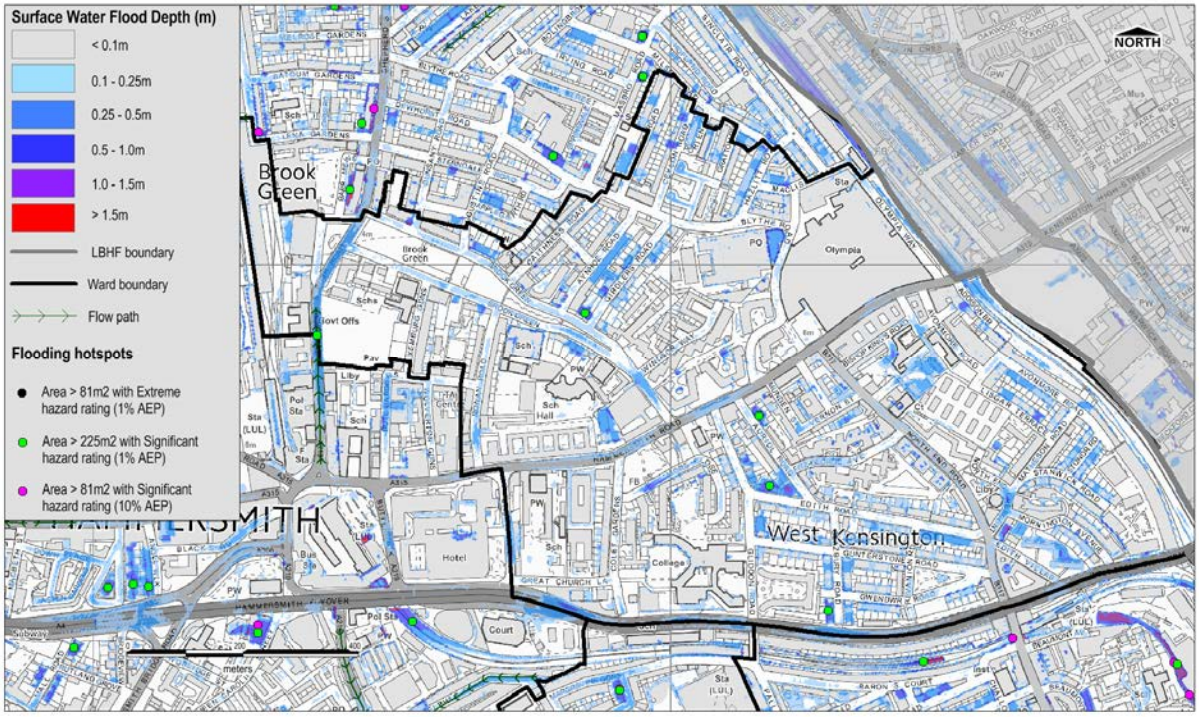


Figure 3.8-15 Avonmore and Brook Green 1% AEP maximum modelled flood depth

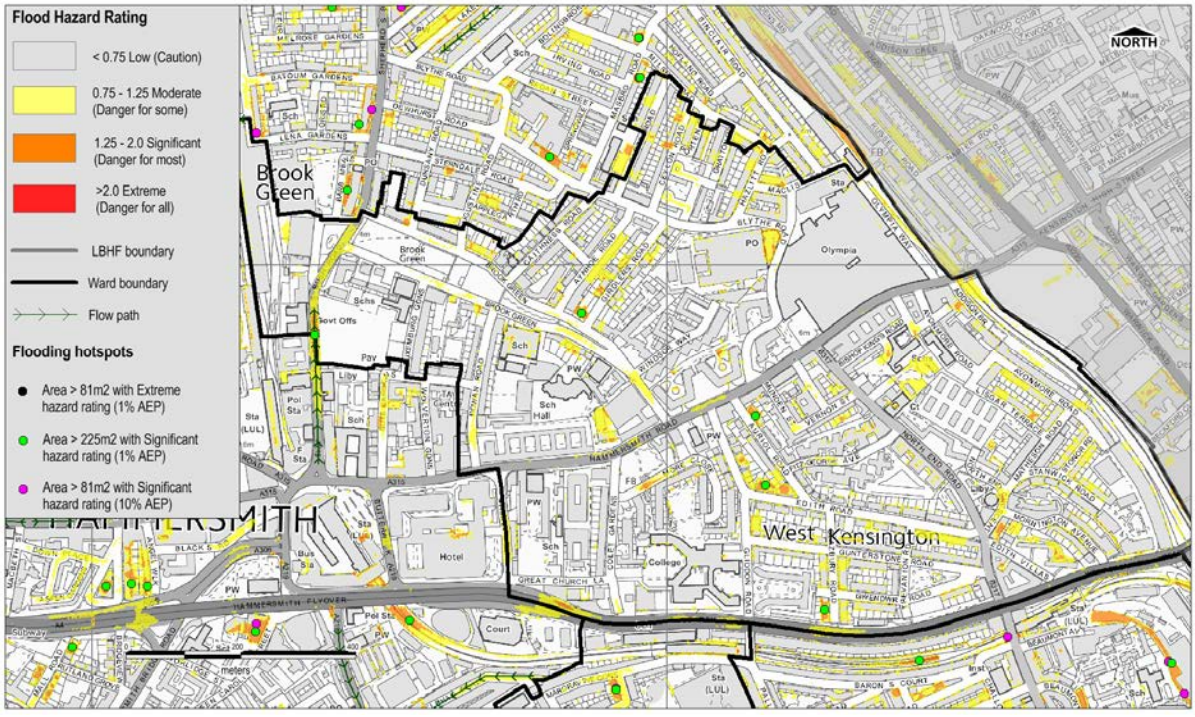


Figure 3.8-16 Avonmore and Brook Green 1% AEP maximum modelled flood hazard

Ward Area 8: Avonmore and Brook Green	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	In the west of the Ward the modelling results identify flooding of up to 0.5m along Shepherd's Bush Road. Surface water flooding is also modelled to occur Girdlers Road and Aynhoe Road in the north; and along Edith Road, North End Crescent and Glazbury Road in the south.
Flooding Hotspots	There are 4 **flooding hotspots** within the Ward.
Validation	There were 9 Council records of flooding in the Ward during the July 2007 flood event including Hammersmith Road, Blythe Road, Beaconsfield Terrace and Faroe Road in the centre and north of the Ward. There are also records on Edith Road, North End Crescent and Mornington Avenue in the south of the Ward. TfL have 6 records of flooding along the A4 in this location. The Ward is located in postcode area W14 in which there are 400-800 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 595 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 5 More Vulnerable Infrastructure • 0 Other Infrastructure • 26 Commercial / Industrial • 18 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 31 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 3 Commercial / Industrial • 2 Unclassified
Fluvial and Tidal	The western part of the Ward is Flood Zone 1 Low Probability. The central and eastern part is within Flood Zones 1, 2 and 3a. Due to the presence of the Thames Tidal Defences this is a residual risk.
Groundwater	The northern edge and the southern part of the Ward are defined as areas with increased Potential for Elevated Groundwater (iPEG).

Ward Area 9: Fulham Reach

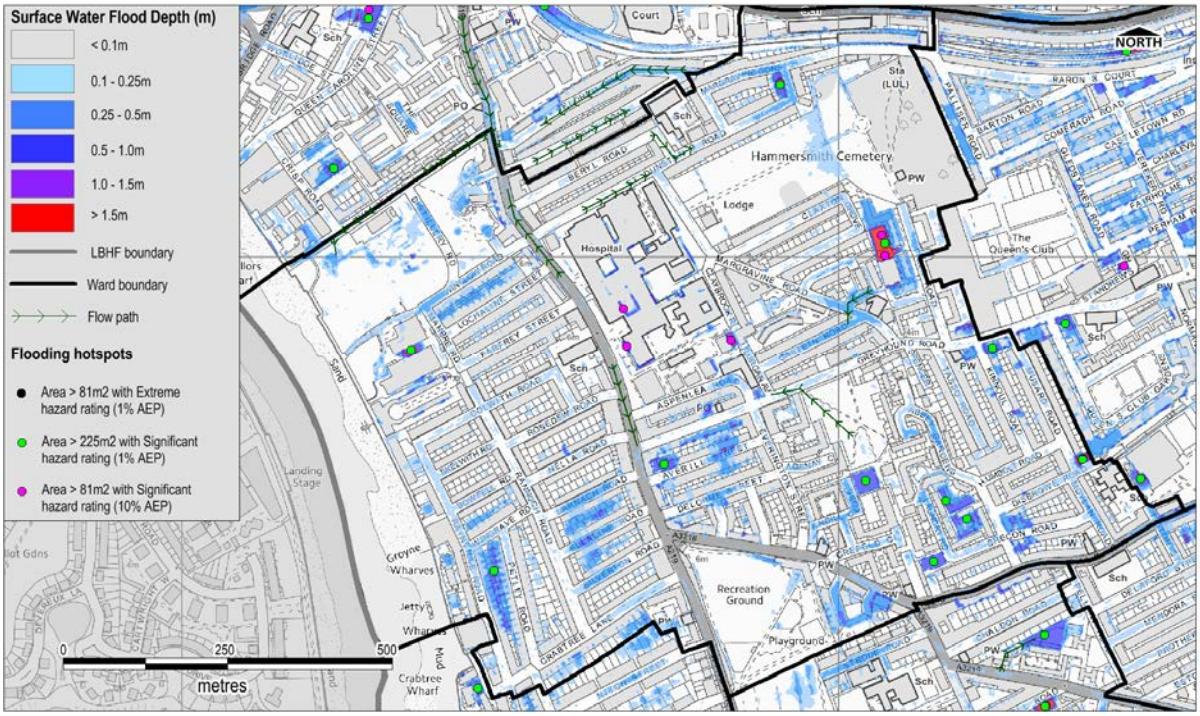


Figure 3.8-17 Fulham Reach 1% AEP maximum modelled flood depth

Figure 3.8-18 Fulham Reach 1% AEP maximum modelled flood hazard

Ward Area 9: Fulham Reach	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	The main areas shown to be at risk of surface water flooding include the areas around Margravine Gardens in the north of the Ward; Field Road in the east; Purcell Crescent in the south, Averill St, Larnach Road, Ellaline Road and Silverton Road in the centre; and Petley Road in the west. On Purcell Crescent surface water tends to be from runoff from the land to the south. Averill St and Aspenlea Road are susceptible to significant surface water flood depths. Runoff from the south (Purcell Crescent area) and the east contribute to the flood depths here. The greatest flood depths within the Ward are found within the properties adjacent to Field Road and Gastein Road. Flood depths here are a result of runoff from the local area and appear to be exacerbated by sewer flooding.
Flooding Hotspots	There are 18 **flooding hotspots** within the Ward.
Validation	There were 5 Council records of flooding in this Ward during the July 2007 flood event along Greyhound Road, Averill Road and Musard Road in the centre of the Ward. There are 3 records of flooding on the A4 Talgarth Road recorded by TfL. The Ward is located in postcode area W6 in which there are 400-800 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 294 Residential Properties • 1 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 33 Commercial / Industrial • 21 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 32 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 0 Commercial / Industrial • 3 Unclassified
Fluvial and Tidal	The Ward is within Flood Zone 3a High Probability of Flooding from rivers and the sea. Due to the presence of the Thames Tidal Defences this is a residual risk.
Groundwater	The eastern half of the Ward is defined as an area with iPEG.

Ward Area 10: North End

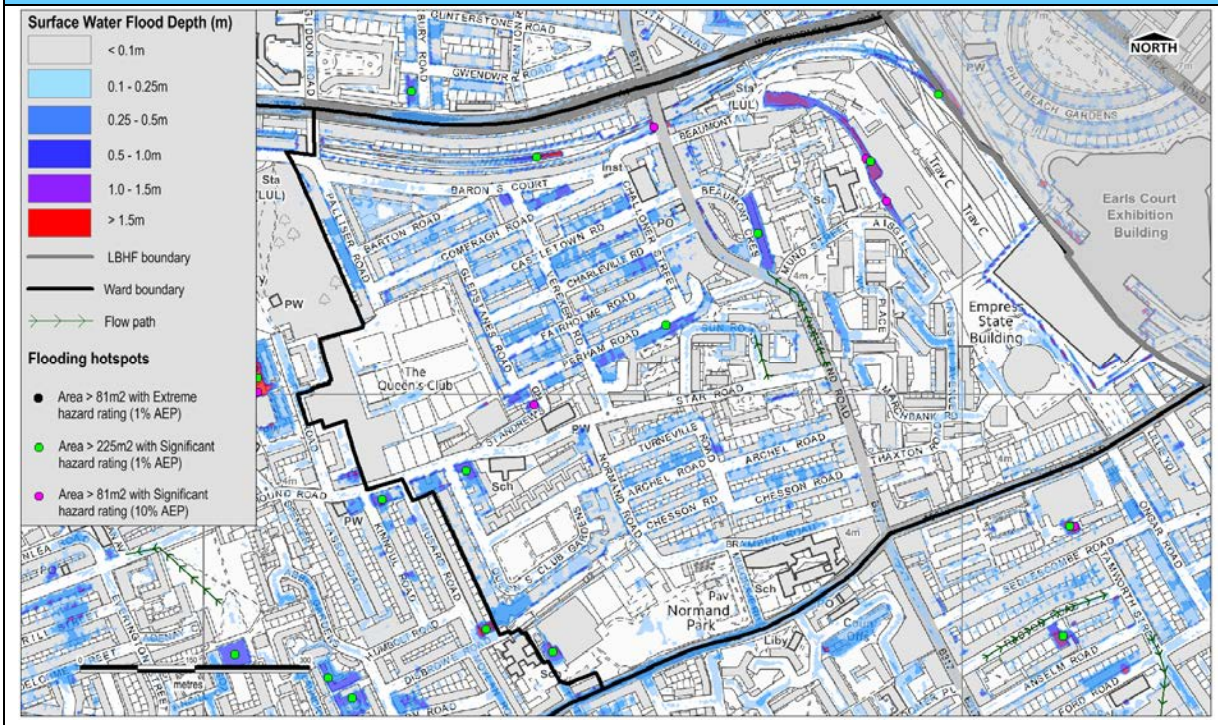


Figure 3.8-19 North End 1% AEP maximum modelled flood depth

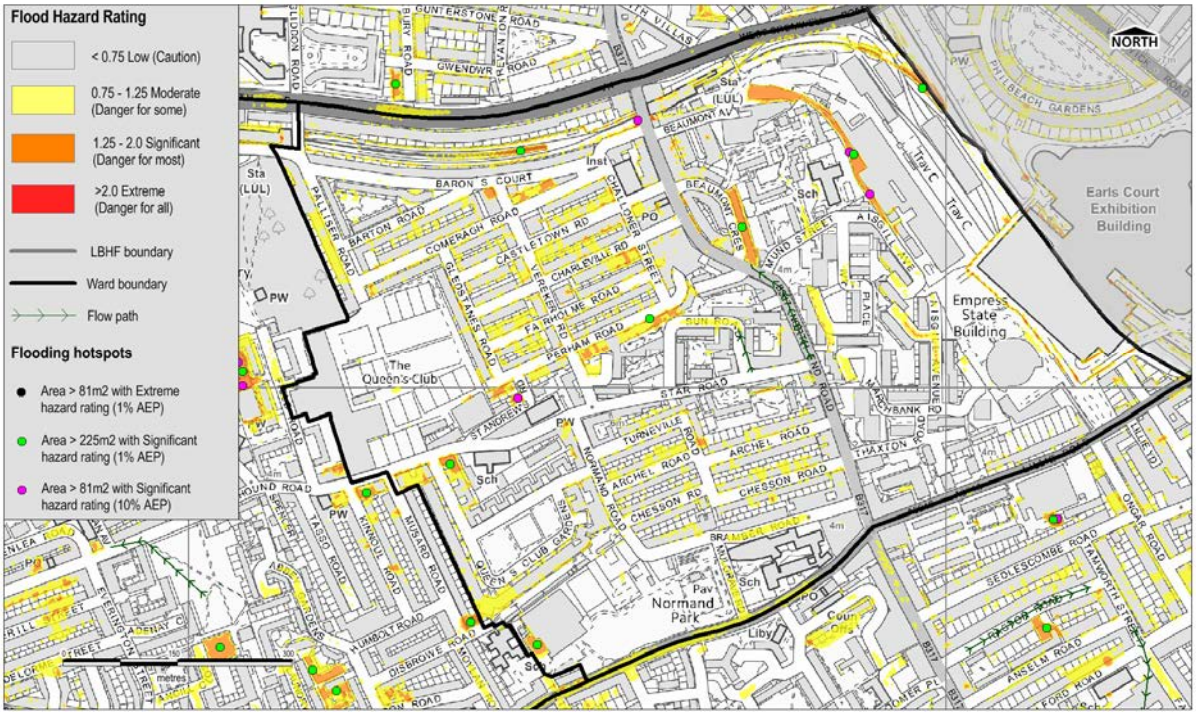


Figure 3.8-20 North End 1% AEP maximum modelled flood hazard

Ward Area 10: North End	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	The surface water modelling shows that the areas of greater flood risk are located in the north of the Ward. Surface water modelling results indicate that flood depths are greatest around the areas of Beaumont Crescent and the regular network of roads to the west of the B317 North End Road. The main flow paths to this point are along North End Road and Sun Road. Surface water is also shown to pond adjacent to the LUL railway line along the north of the Ward. The flood depths on Beaumont Crescent are likely to be exacerbated by surcharging sewers along Ivatt Place, Mund Street and Aisgill Avenue.
Flooding Hotspots	There are 11 **flooding hotspots** within the Ward.
Validation	There were 6 Council records of flooding in this Ward during the July 2007 flood event. These are chiefly located in the north west of the Ward along Castletown Road and Comeragh Road, as well as along Aisgill Avenue in the east. TfL have 2 records of flooding on West Cromwell Road (A4). The Ward is located in postcode area W14 in which there are 400-800 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 746 Residential Properties • 1 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 15 Commercial / Industrial • 20 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 51 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 1 Commercial / Industrial • 0 Unclassified
Fluvial and Tidal	The majority of the Ward is defined as Flood Zone 3a. Due to the presence of the Thames Tidal Defences this is a residual risk.
Groundwater	This Ward is defined as an area increased Potential for Elevated Groundwater (iPEG).

Ward Area 11: Palace Riverside

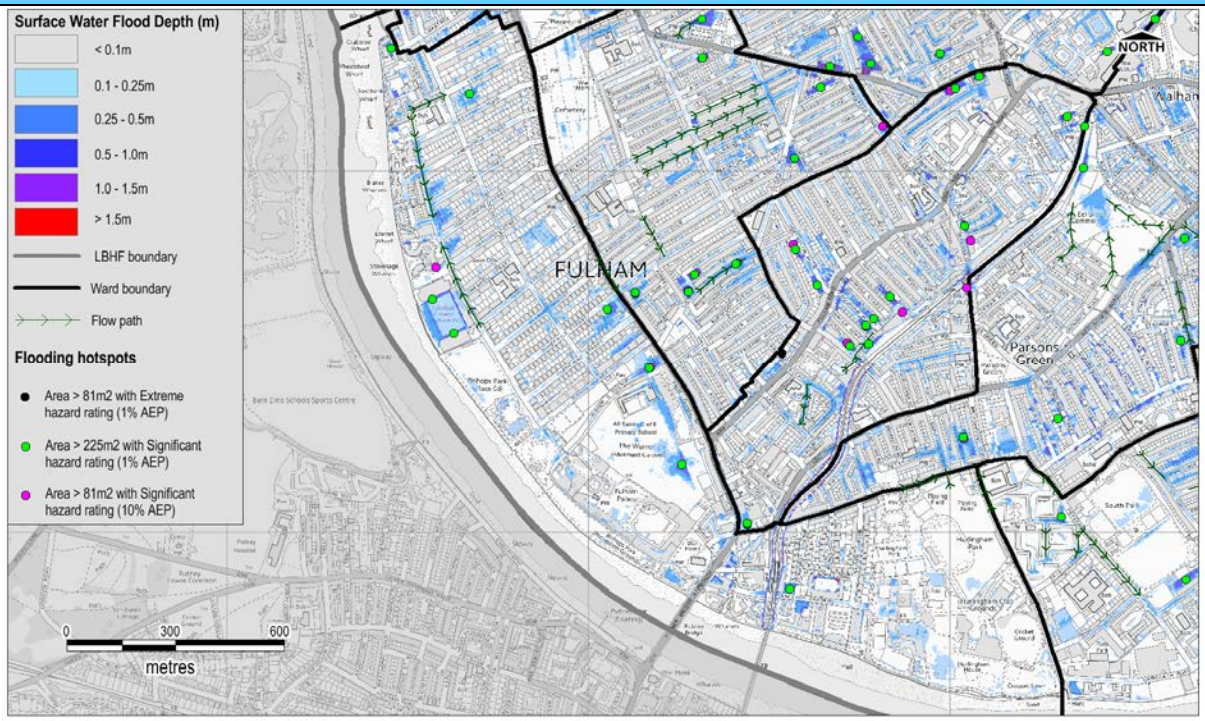


Figure 3.8-21 Palace Riverside 1% AEP maximum modelled flood depth

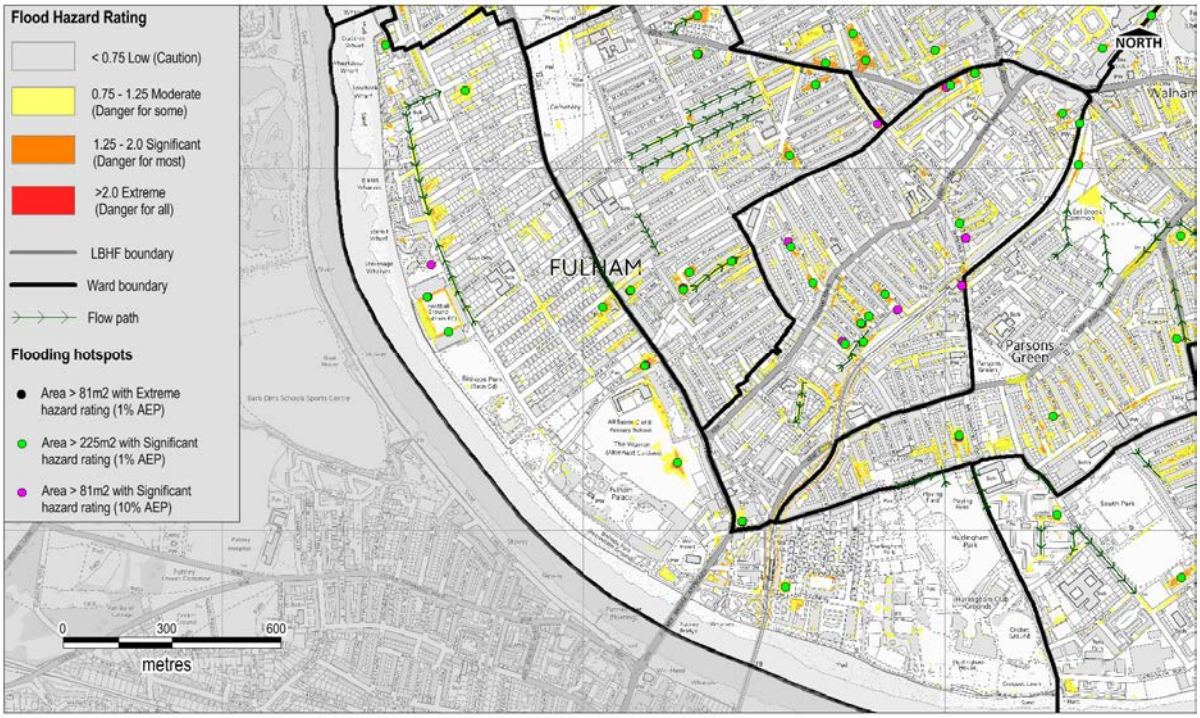


Figure 3.8-22 Palace Riverside 1% AEP maximum modelled flood hazard

Ward Area 11: Palace Riverside	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	The surface water modelling identifies Stevenage Road in the north of the Ward to be susceptible to surface water ponding. Properties adjacent to Fulham Palace Road on the east of the Ward are also shown to be at risk, including properties on Ellerby Street, Finlay Street and Bishops Avenue. The grounds of All Saints Primary School are also shown to be susceptible to ponding. In the south of the Ward, properties on Ranelagh Gardens and Edenhurst Avenue are shown to be at risk.
Flooding Hotspots	There are 11 **flooding hotspots** within the Ward.
Validation	There were 2 Council records of flooding in the Ward during the July 2007 flood event, along Niton Street in the north and Ellerby Street in the centre. The Ward is located in the wider postcode area SW6 in which there are more than 800 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 66 Residential Properties • 2 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 1 More Vulnerable Infrastructure • 0 Other Infrastructure • 60 Commercial / Industrial • 17 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 4 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 0 Commercial / Industrial • 0 Unclassified
Fluvial and Tidal	The Ward is within Flood Zone 3a High Probability of Flooding from rivers and the sea. Due to the presence of the Thames Tidal Defences this is a residual risk.
Groundwater	There is a small area with increased Potential for Elevated Groundwater (iPEG) near Harbord Street in the north of the Ward and near Hurlingham House in the south east.

Ward Area 12: Munster

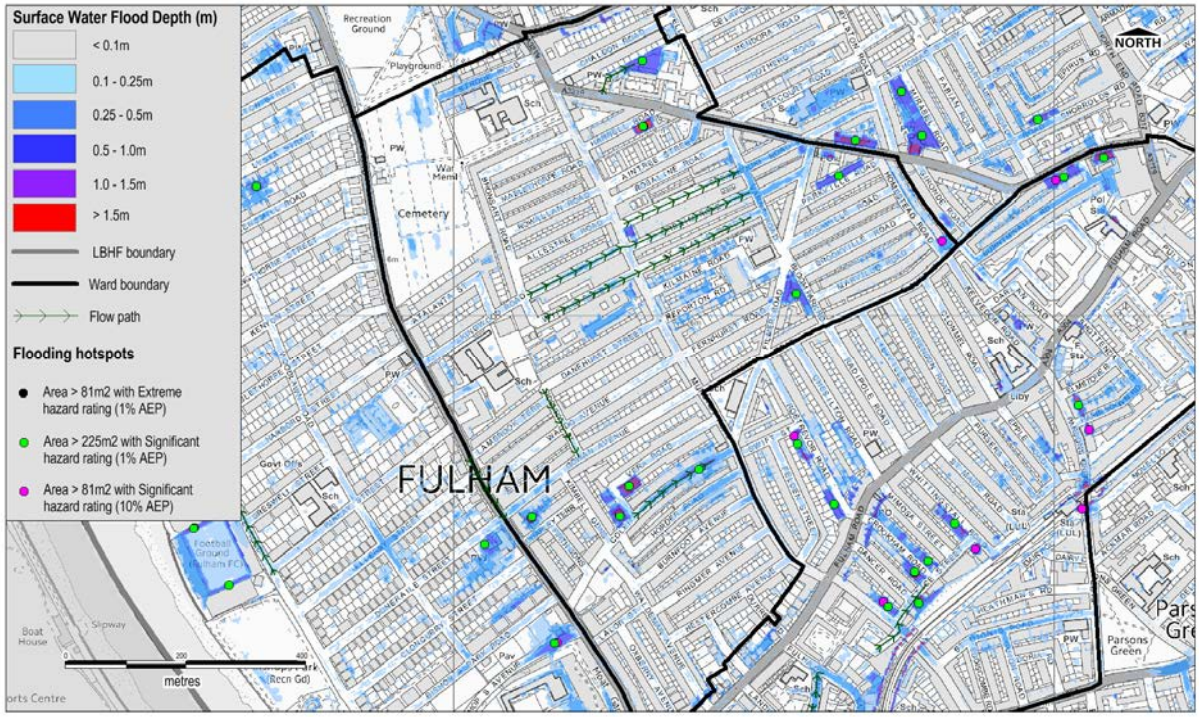


Figure 3.8-23 Munster 1% AEP maximum modelled flood depth

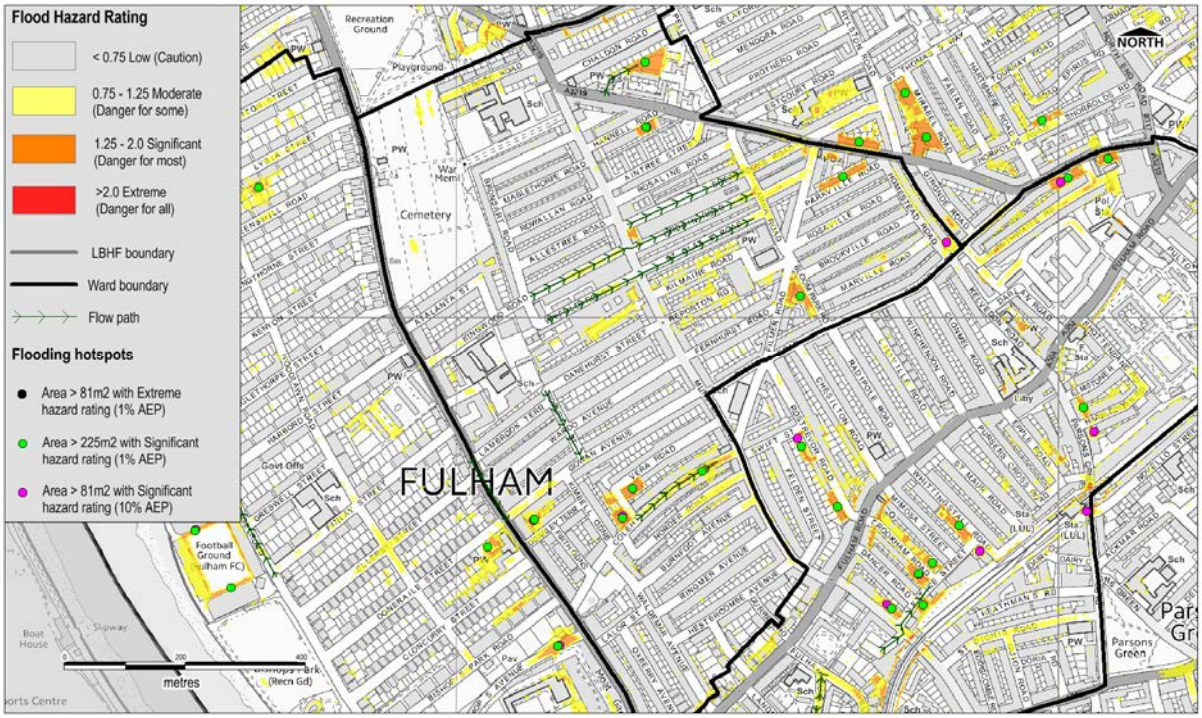


Figure 3.8-24 Munster 1% AEP maximum modelled flood hazard

Ward Area 12: Munster	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	In this Ward surface water is shown to flow in a north easterly direction towards Dawes Road. Main flow paths include Kingwood Road, Sherbrooke Road and St Olaf's Road, amongst others. Surface water flooding is exacerbated by sewer flooding across the area. On Williams Close, near Chaldon Road in the north of the Ward, surface water modelling suggests significant flood depths at this point due to the low lying nature of the property. Main flow is from Dawes Road to the south. In the south of the Ward, modelling suggests flooding along Colehill Lane, Vera Road and Edgarley Terrace. Surface water flows to the area from the north along Sidbury Street and the A219.
Flooding Hotspots	There are 12 **flooding hotspots** within the Ward.
Validation	There were 6 Council records of flooding in the Ward during the July 2007 flood event, which correlate closely to the modelling results on Gowan Avenue, Homestead Road and Sherbrooke Road. Records are also held for properties on Kilmain Road, Reporton Road and Bishops Road. The records are predominately associated to the flooding of basement properties. The Ward is located in postcode area SW6 in which there are more than 800 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 262 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 1 More Vulnerable Infrastructure • 0 Other Infrastructure • 60 Commercial / Industrial • 4 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 54 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 4 Commercial / Industrial • 1 Unclassified
Fluvial and Tidal	The northern part of the Ward is within Flood Zone 1 Low Probability of Flooding from rivers and the sea. The southern half of the Ward is within Flood Zone 3aHigh Probability. Due to the presence of the Thames Tidal Defences this risk is residual.
Groundwater	The eastern part of the Ward is defined as an area with increased Potential for Elevated Groundwater (iPEG).

Ward Area 13: Fulham Broadway

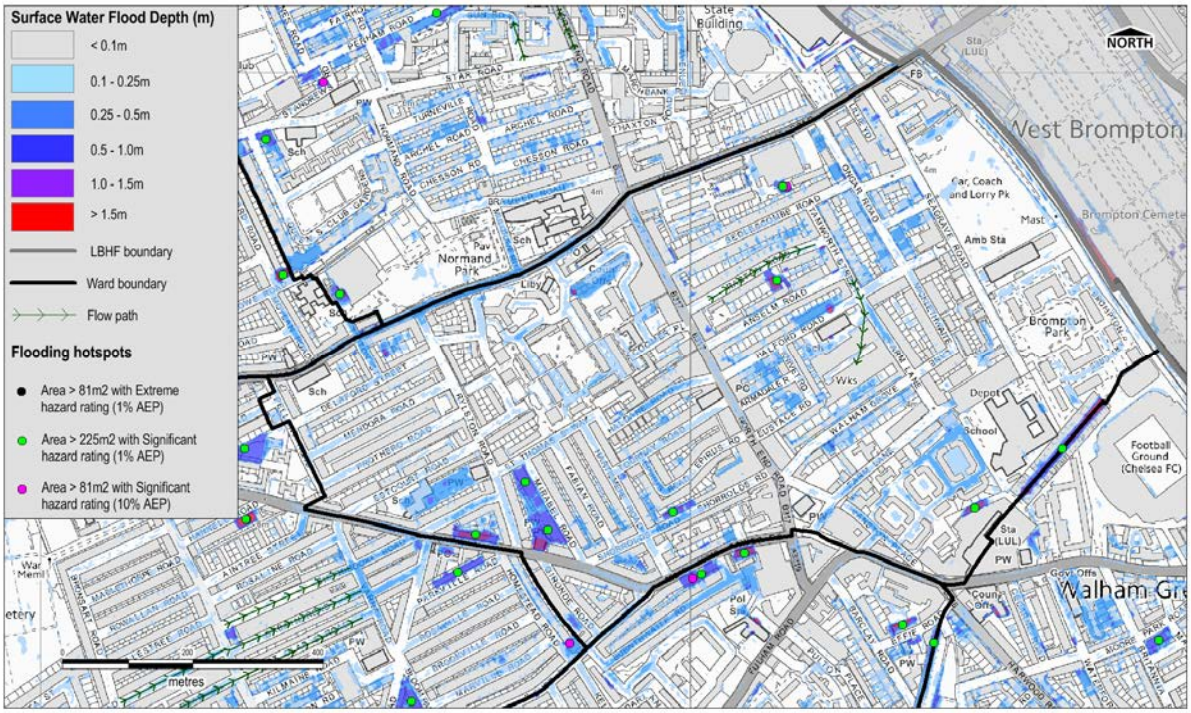


Figure 3.8-25 Fulham Broadway 1% AEP maximum modelled flood depth

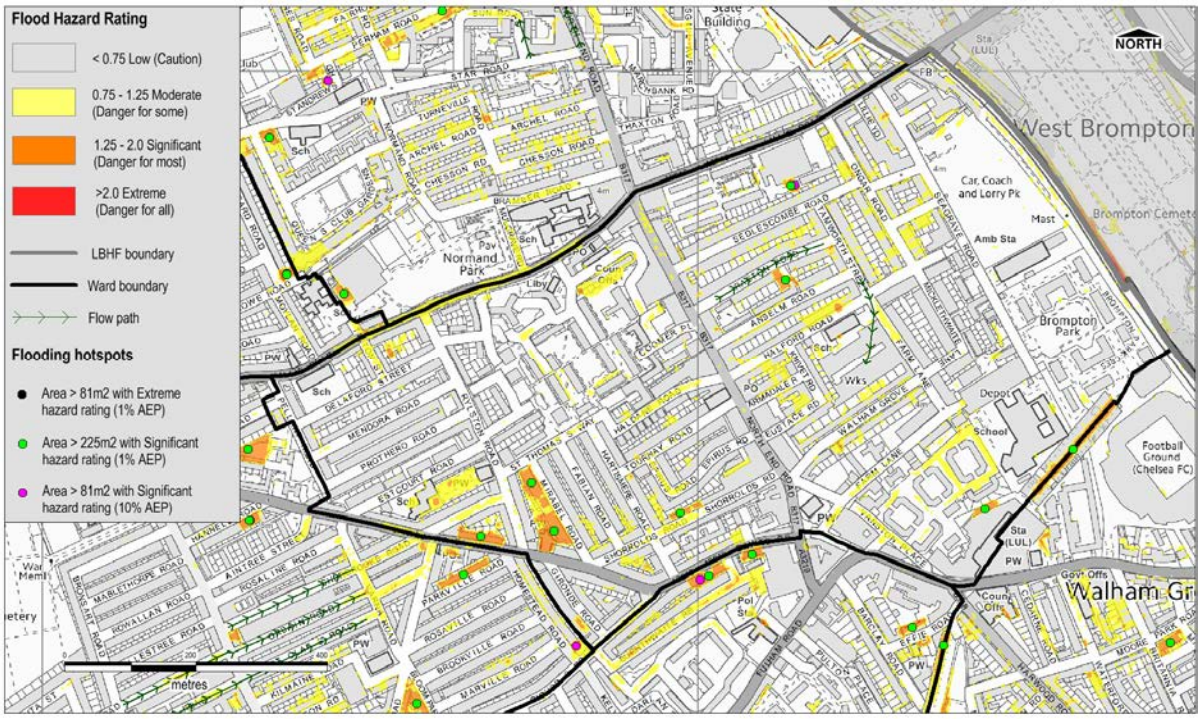


Figure 3.8-26 Fulham Broadway 1% AEP maximum modelled flood hazard

Ward Area 13: Fulham Broadway	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	The main flow paths for surface water are along Racton Road and Tamworth Street. The SWMP modelling indicates the tendency for surface water to flow within the gardens of the properties along Anselm Road, Racton Road, and Walham Grove in the centre of the Ward, as well as Ongar Road in the north and Mirabel Road and Shorrolds Road in the south. Surface water ponding is also shown to occur in the grounds of St Thomas of Canterbury Primary School, and The London Oratory School.
Flooding Hotspots	There are 10 **flooding hotspots** within the Ward.
Validation	There were 6 Council records of flooding in the Ward during the July 2007 flood event, which are concentrated in the centre and north of the Ward on Tamworth Street, Ongar Road, Lillie Road, Eprius Road and Shorrolds Road. The Ward is located in postcode area SW6 in which there are more than 800 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 357 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 2 More Vulnerable Infrastructure • 1 Other Infrastructure • 8 Commercial / Industrial • 27 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 49 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 1 Other Infrastructure • 2 Commercial / Industrial • 0 Unclassified
Fluvial and Tidal	The eastern half of the Ward is within Flood Zone 3a High Probability of flooding and the western half is within Flood Zone 2 Medium Probability. Due to the presence of the Thames Tidal Defences this is a residual risk.
Groundwater	This Ward is defined as an area with increased Potential for Elevated Groundwater (iPEG).

Ward Area 14: Town

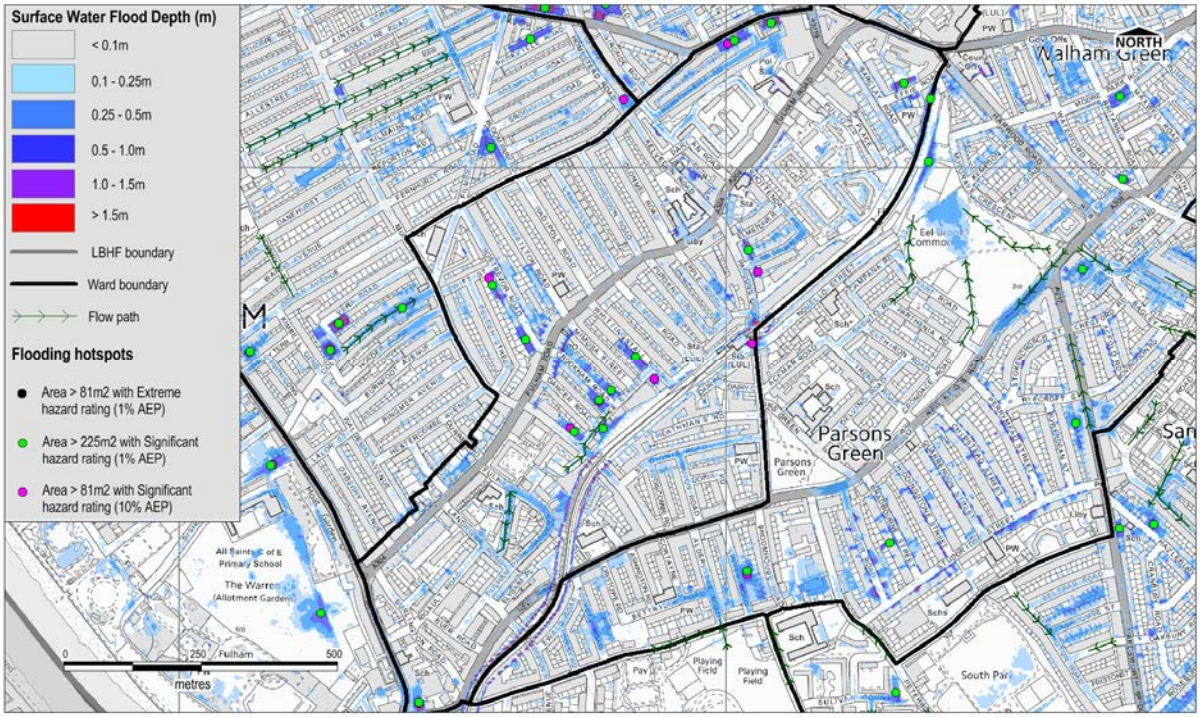


Figure 3.8-27 Town 1% AEP maximum modelled flood depth

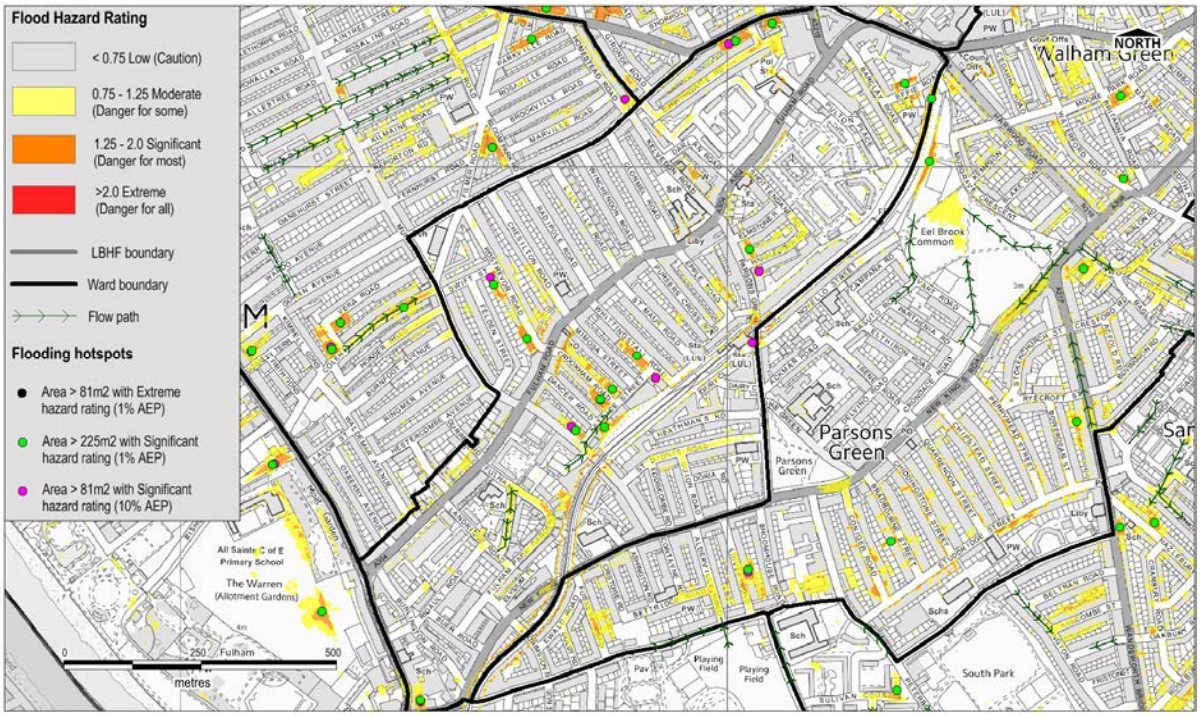


Figure 3.8-28 Town 1% AEP maximum modelled flood hazard

Ward Area 14: Town	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	The surface water modelling indicates the potential for basement flooding on Rostrevor Road, Crookham Road, Lettice Street and Whittingstall Road in the centre of the Ward. Surface water flows mainly in a north easterly direction along Fulham Park Road and Lettice Street. The presence of the railway line appears to have an impact on flows along the back of Fulham Park Gardens and Lettice Street, causing water to accumulate behind the embankment. Properties along Burnthwaite Road in the north of the Ward are also shown to be at risk of relatively deep flooding.
Flooding Hotspots	There are 21 **flooding hotspots** within the Ward.
Validation	There were 10 Council records of flooding in the Ward during the July 2007 flood event. Records are clustered in the following locations; Epple Road, A304 Fulham Road, Rostrevor Road, Bishops Road, Crookham Road, Dancer Road and Lettice Street. The Ward is located in the wider postcode area SW6, in which there are more than 800 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 334 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 3 More Vulnerable Infrastructure • 2 Other Infrastructure • 40 Commercial / Industrial • 30 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 81 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 2 Commercial / Industrial • 3 Unclassified
Fluvial and Tidal	The Ward is within Flood Zone 3a High Probability of Flooding from rivers and the sea. Due to the presence of the Thames Tidal Defences this is a residual risk.
Groundwater	The northern eastern half of the Ward is defined as an area with increased Potential for Elevated Groundwater (iPEG).

Ward Area 15: Parsons Green and Walham

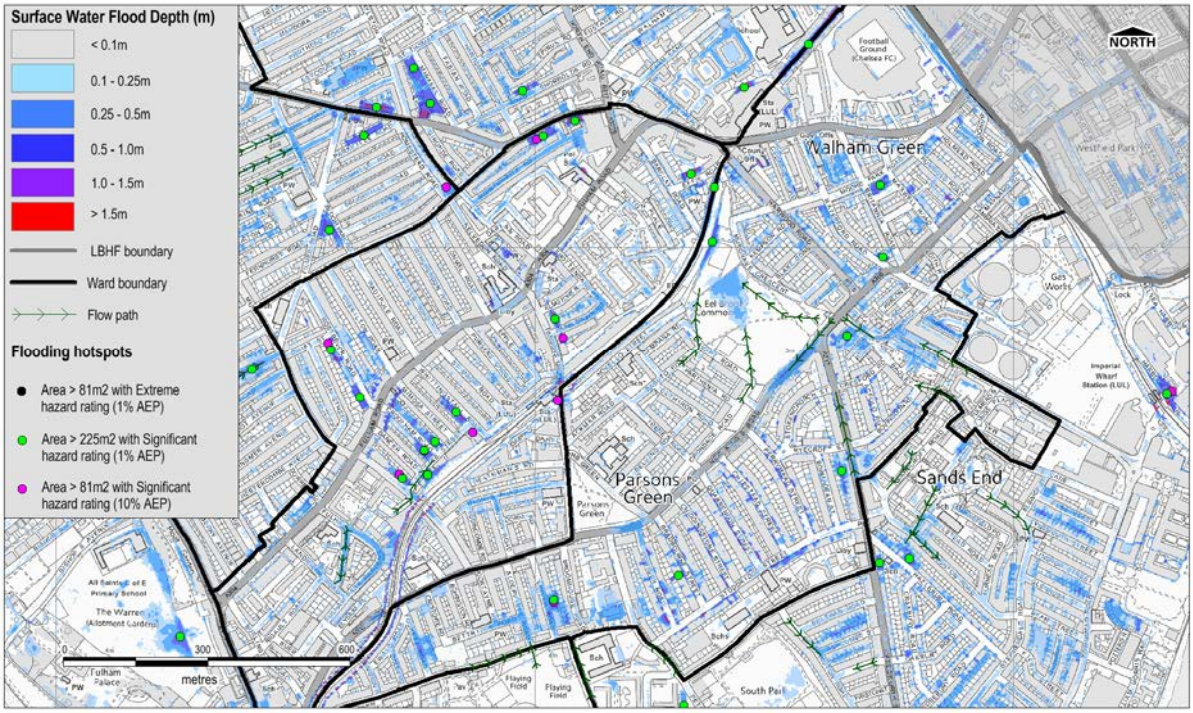


Figure 3.8-29 Parsons Green and Walham 1% AEP maximum modelled flood depth

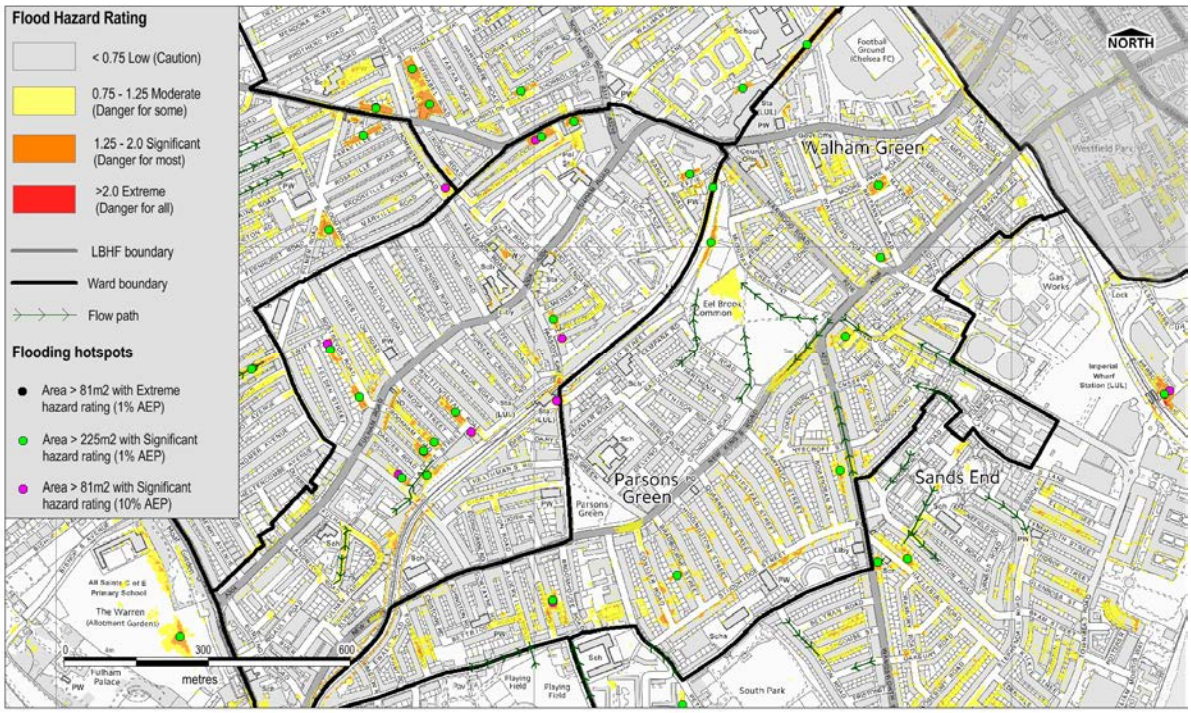


Figure 3.8-30 Parsons Green and Walham 1% AEP maximum modelled flood hazard

Ward Area 15: Parsons Green and Walham	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	Surface water modelling identifies properties in the south of the Ward to be at risk of flooding; e.g. Linver Road, Bettridge Road and Alderville Road, Coniger Road, Bradbourne Street. Further north, flooding is shown to occur along New King's Road adjacent to Eel Brook Common as well as Cheryls Close and Harwood Terrace. In the north of the Ward, surface water is shown to pond adjacent to Moore Park Road, Waterford Road and Cedarne Road.
Flooding Hotspots	There are 8 **flooding hotspots** within the Ward.
Validation	There were 15 Council records of flooding in the Ward during the July 2007 flood event. These records correlate well with modelling results. Records are located along the following streets; Coniger Road, Studdridge Street, Broomhouse Road, Linver Road, Stokenchurch St. Harwood Terrace, New King's Road, Waterford Road and Basuto Road. The Ward is located in the wider postcode area SW6, in which there are more than 800 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 553 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 1 More Vulnerable Infrastructure • 0 Other Infrastructure • 43 Commercial / Industrial • 31 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 31 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 1 Commercial / Industrial • 0 Unclassified
Fluvial and Tidal	The Ward is within Flood Zone 3a High Probability of Flooding from rivers and the sea. Due to the presence of the Thames Tidal Defences this is a residual risk.
Groundwater	The majority of the Ward is defined as an area with increased Potential for Elevated Groundwater (iPEG).

Ward Area 16: Sands End

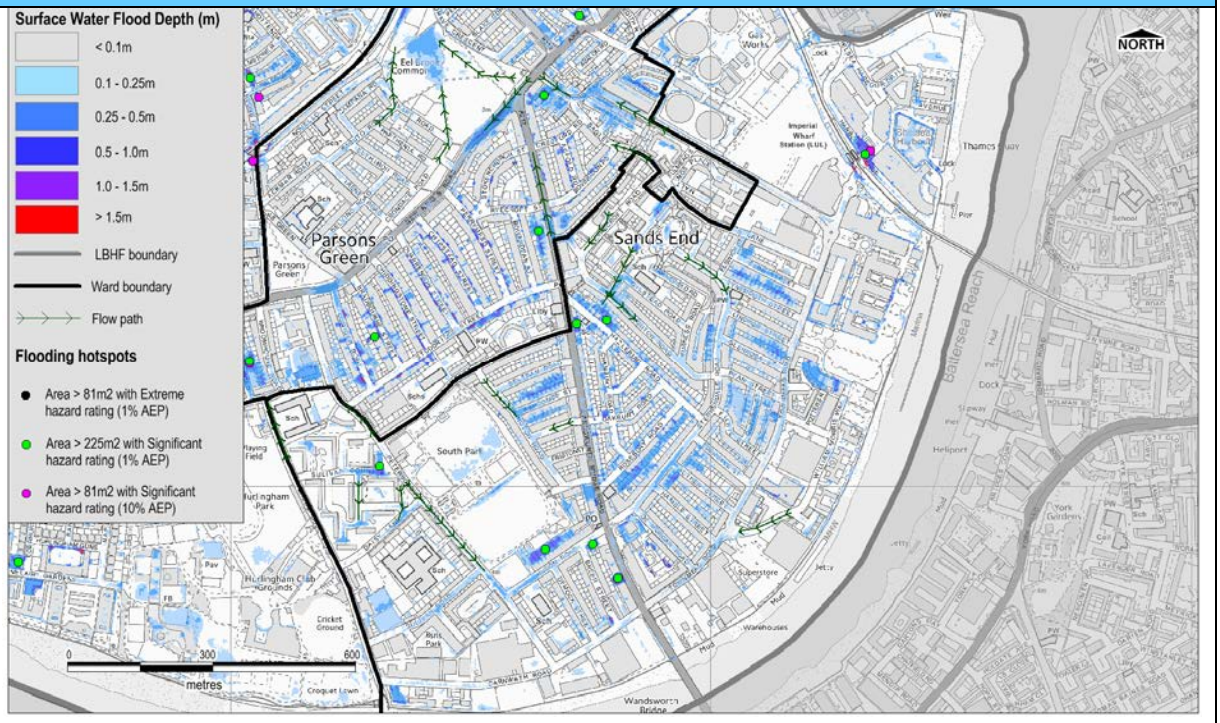


Figure 3.8-31 Sands End 1% AEP maximum modelled flood depth

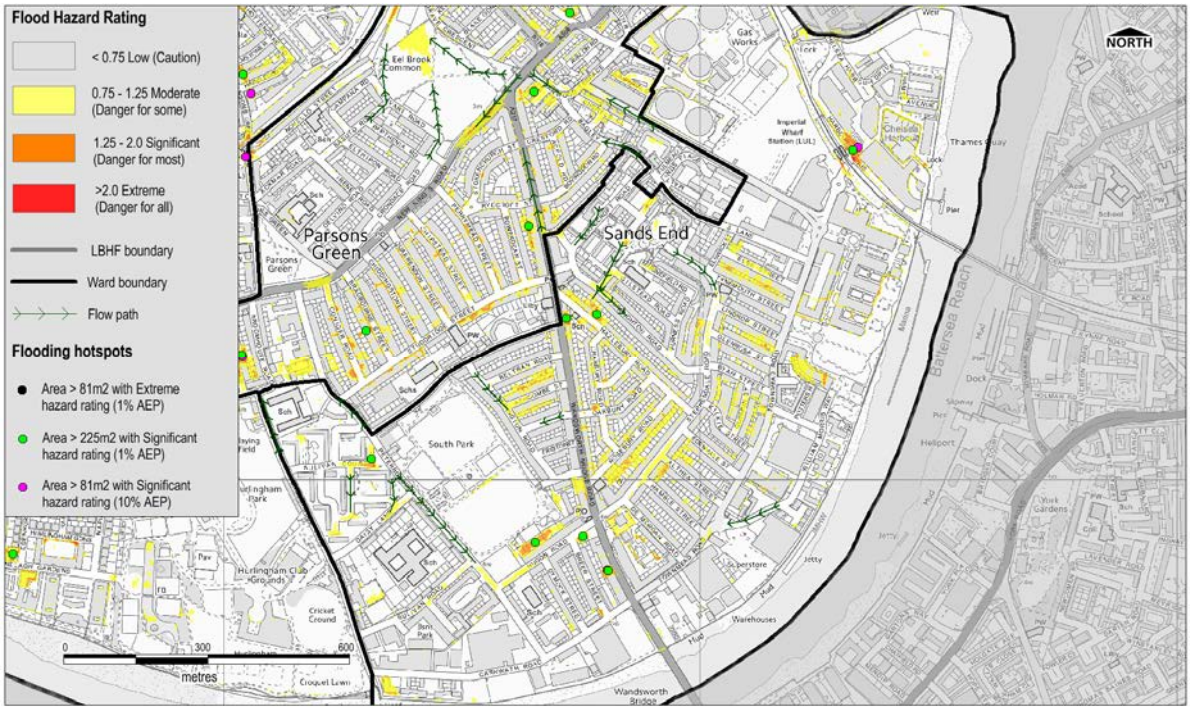


Figure 3.8-32 Sands End 1% AEP maximum modelled flood hazard

Ward Area 16: Sands End	
Flood Risk Categorisation	Surface water, sewer, groundwater, tidal (residual).
Surface Water	The results of the surface water modelling suggest that the central part of the Ward is at greater risk of surface water flooding, which reflects the slightly lower ground levels in this area. Surface water is shown to affect properties along Hugon Road, Rosebury Road, Ashcombe Street, Beltran Road, Querrin Street, Hazlebury Street, Lindrop Street and Esbe Street.
Flooding Hotspots	There are 16 **flooding hotspots** within the Ward.
Validation	There were 5 Council records of flooding in the Ward during the July 2007 flood event. These are chiefly located in the centre of the Ward to the east of Wandsworth Bridge Road, along Hazlebury Road and Stephendale Road. The Ward is located in the wider postcode area SW6, in which there are more than 800 properties on the Thames Water DG5 Register.
Property Count	At risk of flooding to a depth >0.1m (1% AEP): • 392 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 1 Other Infrastructure • 13 Commercial / Industrial • 38 Unclassified At risk of flooding to a depth >0.5m (1% AEP): • 27 Residential Properties • 0 Essential Infrastructure • 0 Highly Vulnerable Infrastructure • 0 More Vulnerable Infrastructure • 0 Other Infrastructure • 0 Commercial / Industrial • 2 Unclassified
Fluvial and Tidal	The Ward is within Flood Zone 3a High Probability of Flooding from rivers and the sea. Due to the presence of the Thames Tidal Defences this is a residual risk.
Groundwater	The central part of the Ward is defined as an area with increased Potential for Elevated Groundwater (iPEG).

3.9 Summary of Risk

Overview of Surface Water Flooding

3.9.1 The detailed assessment of surface water and sewer flooding, along with the analysis of historic flood records, shows that there is a significant risk of surface water and sewer flooding within the LBHF.

3.9.2 The following conclusions can be drawn:

- Surface water flooding is predominantly the result of the low lying nature of the Borough in relation to the surrounding area. As described in Section 1.4, the central and southern sections of the Borough have a very slight slope. This has the effect of allowing surface water to accumulate locally. Low lying features, such as railway cuttings and underpasses are also more susceptible to surface water flooding.
- Surface water generally flows in channels created by the structures of the roads. Other features of the urban environment, such as railway embankments, or underpasses, also influence overland flow paths.
- Within the SWMP baseline model, the sewer network functions transfer surface water across the catchment resulting in surcharging sewers downstream of the network contributing to surface water flooding.
- The main areas identified to be at risk of surface water flooding are the Wards of Askew (127 properties modelled to be at risk of flooding to a depth >0.5m during the 1% AEP rainfall event and 134 Council records of flooding), Hammersmith Broadway (103 properties modelled to be at risk of flooding to a depth >0.5m during the 1% AEP rainfall event and 125 Council records of flooding), Addison (80 properties modelled to be at risk of flooding to a depth >0.5m during the 1% AEP rainfall event and 84 Council records of flooding), and Town (86 properties modelled to be at risk of flooding to a depth >0.5m during the 1% AEP rainfall event and 96 Council records of flooding).
- The baseline modelling indicates sewer flooding to occur across the Borough area, with the greatest frequency of events occurring around Brook Green, Paddenswick Road, Wendell Park, Cathnor Park, Sands End and Eel Brook Common. The sewer network was found to be at capacity for a short duration during the 10% AEP event. As the magnitude of the rainfall events increased, the sewer network reached capacity more rapidly and remained at capacity for a greater duration.

3.9.3 Flooding within the areas of Shepherd's Bush and Wendell Park are impacted from upstream surface water flows from the London Borough of Ealing, and it will therefore be important that the flood risk is managed at a catchment scale by both Councils.

Risk to Existing Properties and Infrastructure

3.9.4 As part of the Phase 2 assessment, a quantitative assessment of the number of properties at risk of flooding has been undertaken for each Ward and for the Borough as a whole. The 1% AEP rainfall event has been used to inform this assessment.

3.9.5 The Borough-wide quantitative assessment is provided in Table 3-7. Table 3-8 provides a summary of the flooded properties for each of the 16 Wards within LBHF alongside information on the various property categories used, and methodology for defining these. The property count has been calculated for infrastructure, households and commercial/industrial properties for the 1% AEP rainfall event.

Table 3-7 Borough-Wide Summary of Flood Risk (1% AEP Rainfall Event)

Property Type	Sub Category	No. of properties flooded >0.1m	No. of properties flooded >0.5m
Residential	20% Most deprived	1,268	170
	20 – 40% Most deprived	3,780	407
	60% Least deprived	2,011	268
	Subtotal residential	***7,059***	***845***
Infrastructure	Essential Infrastructure	7	0
	Highly Vulnerable	2	0
	More Vulnerable	22	1
	Other Infrastructure	8	3
	Subtotal Infrastructure	***39***	***4***
Commercial/Industrial		441	21
Unclassified		409	39
Total		**850**	**60**

Table 3-8 Summary of Surface Water Flood Risk *(based on pluvial modelling results for the 1% AEP rainfall event).*

ID	Ward	Residential						Infrastructure								Commercial / Industrial		Unclassified		Total	
		20% Most Deprived		20 – 40% Most Deprived		60% Least Deprived		Essential		Highly Vulnerable		More Vulnerable		Other							
		>0.1m	> 0.5m	>0.1m	> 0.5m	>0.1m	> 0.5m	>0.1m	> 0.5m	>0.1m	> 0.5m	>0.1m	> 0.5m	>0.1m	> 0.5m	>0.1m	> 0.5m	>0.1m	> 0.5m	>0.1m	> 0.5m
1	College Park and Old Oak	46	1	31	1	0	0	1	0	0	0	2	0	0	0	16	2	51	9	**147**	**13**
2	Wormholt and White City	137	17	260	57	0	0	1	0	0	0	0	0	0	0	5	0	14	0	**417**	**74**
3	Shepherd's Bush Green	91	19	327	29	0	0	1	0	0	0	0	0	0	0	14	0	21	0	**454**	**48**
4	Askew	414	79	349	41	0	0	0	0	0	0	2	1	1	1	20	0	29	5	**815**	**127**
5	Ravenscourt Park	121	9	145	38	150	23	0	0	2	0	1	0	2	1	14	0	32	8	**467**	**79**
6	Hammersmith Broadway	169	20	440	70	109	11	0	0	0	0	2	0	0	0	30	1	33	1	**783**	**103**
7	Addison	133	15	202	8	336	47	0	0	0	0	2	0	1	0	44	5	23	5	**741**	**80**
8	Avonmore and Brook Green	18	0	410	16	167	15	0	0	0	0	5	0	0	0	26	3	18	2	**644**	**36**
9	Fulham Reach	0	0	165	29	129	3	1	0	0	0	0	0	0	0	33	0	21	3	**349**	**35**
10	North End	65	5	556	35	125	11	1	0	0	0	0	0	0	0	15	1	20	0	**782**	**52**
11	Palace Riverside	0	0	0	0	66	4	2	0	0	0	1	0	0	0	60	0	17	0	**146**	**4**
12	Munster	0	0	82	24	180	30	0	0	0	0	1	0	0	0	60	4	4	1	**327**	**59**
13	Fulham Broadway	10	0	272	14	75	35	0	0	0	0	2	0	1	1	8	2	27	0	**395**	**52**
14	Town	1	0	73	21	260	60	0	0	0	0	3	0	2	0	40	2	30	3	**409**	**86**
15	Parsons Green and Walham	45	0	197	13	311	18	0	0	0	0	1	0	0	0	43	1	31	0	**628**	**32**
16	Sands End	18	5	271	11	103	11	0	0	0	0	0	0	1	0	13	0	38	2	**444**	**29**
	Total	**1,268**	**170**	**3,780**	**407**	**2,011**	**268**	**7**	**0**	**2**	**0**	**22**	**1**	**8**	**3**	**441**	**21**	**409**	**39**	**7,948**	**909**

Notes: The summary of risk table is populated by calculating the total number of units from each sub-category that are affected by surface water flooding from the 1% AEP rainfall event. The Infrastructure and Household Sub-Categories are described in Table 3-9 and Table 3-10; further information on these categories and their use is available in the Drain London Data and Modelling Framework.

Table 3-9 Infrastructure Sub-Categories

Category	Description
Essential Infrastructure	• Essential transport infrastructure which has to cross the area at risk • Mass evacuation routes • Tube stations and entrances • Essential utility infrastructure which has to be located in a flood risk area for operation reasons • Electricity generating power stations and grid and primary substations • Water treatment works
Highly Vulnerable	• Police stations, Ambulance stations, Fire stations, Command Centres and telecommunications installations • Emergency disposal points • Installations requiring hazardous substances consent
More Vulnerable	• Hospitals • Health Services • Education establishments, nurseries • Landfill, waste treatment and waste management facilities for hazardous waste • Sewage treatment works • Prisons

Table 3-10 Residential Sub-Categories

Category	Description
Households	• All residential dwellings • Caravans, mobile homes and park homes intended for permanent residential use • Student halls of residence, residential care homes, children's homes, social services homes and hostels
20% Most Deprived Households	• Those households falling into the lowest 20% of ranks by the Office of National Statistics' Indices of Multiple Deprivation.
20 – 40% Most Deprived Households	• Those households falling into the lowest 20 - 40% of ranks by the Office of National Statistics' Indices of Multiple Deprivation.
60% Least Deprived	• Those households not falling into the lowest 40% of ranks by the Office of National Statistics' Indices of Multiple Deprivation

3.10 Ward Prioritisation

3.10.1 It is recognised that it will not be possible to address identified surface water flood risk across the Borough in the short to medium term due to resource and funding constraints. It is therefore important to prioritise areas of greatest risk. The Wards have been prioritised based on the following criteria:

- The number of properties experiencing flooding of >0.5m during the 1% AEP rainfall event;
- The number of most deprived properties experiencing flooding of >0.5m during the 1% AEP rainfall event.

3.10.2 The number of surface water flooding incidents reported in the area. Table 3-11 uses the above mentioned criteria to rank the Wards. The lowest score relates to the Ward with the greatest risk and therefore highest priority. It should be noted that the Wards vary in size, and therefore the information presented in Table 3-11 offers only an indication of where the Council may wish to focus their efforts.

Table 3-11 Ward Prioritisation

Ward (ID)	Properties at risk of flooding >0.5m (1%AEP)		*Most deprived residential* properties at risk of flooding >0.5m (1%AEP)		Council records of flooding		Score
	Number	Rank	Number	Rank	Number	Rank	
Askew (4)	127	1	79	1	20	2	1.3
Hammersmith Broadway (6)	103	2	20	2	28	1	1.7
Addison (7)	80	4	15	5	12	4	4.3
Town (14)	86	3	0	10	10	5	6.0
Shepherd's Bush Green (3)	48	10	19	3	10	5	6.0
Wormholt and White City (2)	74	6	17	4	6	8	6.0
North End (10)	52	9	5	7	6	8	8.0
Ravenscourt Park (5)	79	5	9	6	3	14	8.3
Munster (12)	59	7	0	10	6	8	8.3
Parsons Green and Walham (15)	32	13	0	10	15	3	8.7
Fulham Broadway (13)	52	8	0	10	6	8	8.7
Avonmore and Brook Green (8)	36	11	0	10	9	7	9.3
Sands End (16)	51211.029	14	5	7	5	12	11.0
Fulham Reach (9)	35	12	0	10	0	12	11.3
College Park and Old Oak (1)	13	15	1	9	2	16	13.3
Palace Riverside (11)	4	16	0	10	20	15	13.7

3.11 Communicate Risk

Professional Stakeholders

3.11.1 There are various professional stakeholders which are interested in increasing their knowledge of risks from surface water flooding. It is essential that the SWMP partnership actively engages with these groups, where appropriate, to share the findings of this report. This will ensure that emerging plans and policies are informed by the latest evidence contributing to an improved understanding of surface water flood risk issues.

3.11.2 Appendix C – Spatial Planning Information Pack and Appendix D – Resilience Forum and Emergency Planner Information Pack provide guidance on how the SWMP outputs should be used in updating existing planning documents, such as Strategic Flood Risk Assessments (SFRAs) and Multi-Agency Flood Plans (MAFPs), and informing emerging planning policy and spatial planning decisions.

Recommendation 8: Actively engage with professional stakeholders to communicate findings of SWMP and local flood risk management.

Local Resilience Forums

3.11.3 It is strongly recommended that the information provided in the SWMP is issued to the Local Resilience Forum. Surface water flood maps and knowledge of historic flood events should be used to update Incident Management Plans, Community Risk Registers and Multi-Agency Flood Plans for the area. It is recommended that the results of the intermediate pluvial modelling are used to identify likely flow-paths and locations of ponding of surface water. This information can be used in parallel with Extreme Rainfall Alert (ERA) service provided by the Flood Forecasting Centre[viii]. In addition, maps showing the depth of pluvial flooding during a range of return period rainfall events can be used to inform operations undertaken by emergency response teams especially near public buildings and major routes through the Borough.

Communication and Engagement Plan

3.11.4 It is recommended that a Communication and Engagement Plan should be produced for the LBHF to effectively communicate and raise awareness of surface water flood risk to different audiences using a clearly defined process for internal and external communication with stakeholders and the public.

3.11.5 The Plan should:

- Develop clear key messages from the SWMP (and PFRA) relating to local surface water flood risk and management;
- Create simplified maps and meaningful data for communications materials;
- Clearly define a structure for internal and external (multi-agency) partnership working (based on the partnership structure identified in Phase 1 of the SWMP); and
- Provide a strategy for communicating the SWMP findings to political stakeholders, local resilience forum members, Regional Flood and Coastal Defence Committee

[viii] The Flood Forecasting Centre was set up in 2008 by the Met Office and the Environment Agency to provide services to emergency and professional partners.

members and the general public and engaging these parties in future local flood risk management actions.

Recommendation 9: Design and gain buy-in to a Communication and Engagement Plan to identify how to effectively communicate and raise awareness of local flood risk to different audiences.

4 PHASE 3: OPTIONS

4.1 Objectives

4.1.1 The purpose of Phase 3 is to identify a range of structural and non-structural options for alleviating flood risk in the LBHF and assess them to eliminate those that are not feasible. The remaining options are then developed and tested against their relative effectiveness, benefits and costs.

4.1.2 Phase 3 delivers a high level option assessment for the Borough area. No monetised damages have been calculated and flood mitigation costs have been determined using engineering judgement, but have not undergone detailed analysis. As such, the costs provided as part of this study have been assigned to cost bands[ix] to reflect that the costs presented are estimates and not based upon detailed analysis. The options assessment presented is focussed on highlighting areas for further detailed analysis and immediate 'quick win' actions. Further detailed analysis in the future may be undertaken for the high priority areas.

4.2 Methodology

4.2.1 Phase 3 has been undertaken in four stages as summarised below and discussed in more detail in proceeding sections:

- **Stage 1 – Identify Potential Options** (structural and non-structural) based on the standard measures identified by Tier 1 of the Drain London project for all Wards irrespective of the costs or benefits associated with these;
- **Stage 2 – Short List Potential Options** based on a range of social, environmental technical and economic criteria to determine the preferred schemes for consideration in Stage 3 and 4; and
- **Stage 3 – Model Short Listed Options** based on broad scale modelling of preferred options across the Borough. The resulting effect on depth and hazard will be assessed by comparing the results with the baseline model results; and
- **Stage 4 – Determine High-level Costs and Benefits** for short listed potential options using unit costs provided by Tier 1 of the Drain London project and estimating potential benefits to areas at risk of flooding.

Stage 1 Identify Potential Options

4.2.2 This stage aims to identify a number of measures that have the potential to reduce surface water flooding across each of the Wards. It has been informed by the knowledge gained as part of the Phase 1 and Phase 2 assessment. At this stage the option identification pays no attention to constraints, such as funding or delivery mechanisms, to enable a robust assessment.

4.2.3 A standard set of structural[x] and non-structural[xi] measures have been specified by the Drain London Board for consideration within each Ward (Table 4-1) which follow the source-pathway-receptor model (Figure 4.2-1).

[ix] As defined by Drain London Prioritisation Matrix Guidance, the cost bands to be used are: <£25k, £26k - £50k, £51k - £100k, £101k - £250k, £251k - £500k, £501k - £1m, £1m - £10m and >£10m.
[x] Structural measures are considered to be those which require fixed or permanent assets to mitigate flood risks.
[xi] Non-structural measures are those which are responses to urban flood risk that may not involve fixed or permanent facilities, and whose positive contribution to the reduction of flood risk is most likely through a process of influencing behaviour.

Table 4-1 Drain London Structural and Non-Structural Measures for Consideration

Source	Pathway	Receptor
• Green roof • Soakaways • Swales • Permeable Paving • Rainwater Harvesting • Detention Basins	• Increasing capacity in drainage systems • Separation of foul and surface water sewers • Improved maintenance regimes • Managing overland flows • Land management practices	• Improved weather warning • Planning policies to influence development • Temporary or demountable flood defences • Social change, education and awareness • Improved resilience and resistance measures

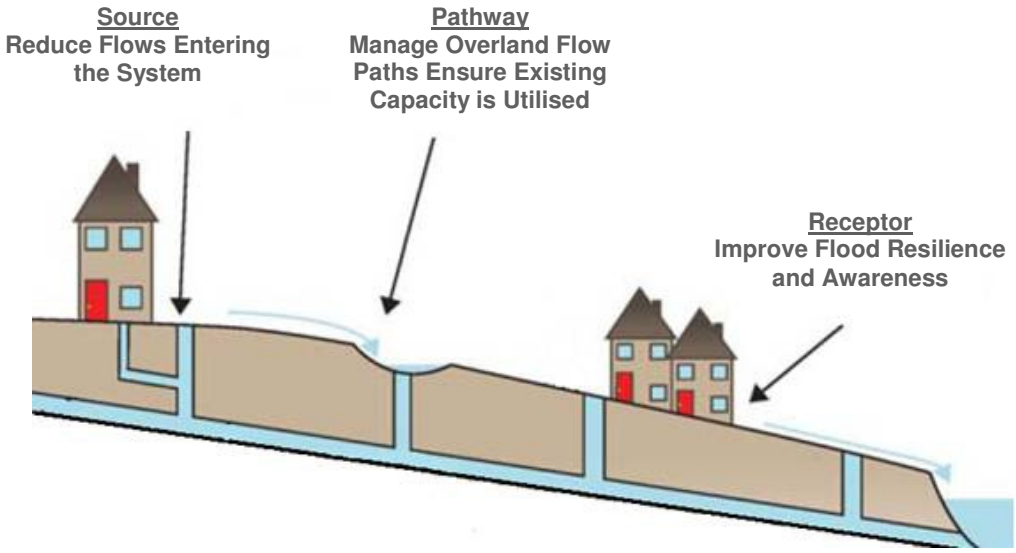


Figure 4.2-1 Source-Pathway-Receptor Model (adapted from SWMP Technical Guidance, 2010)

4.2.4 An opportunity assessment was undertaken for each Ward to evaluate where there were opportunities for the implementation of structural and non-structural measures. The assessment included a review of a technical, economic, social, environmental and flood risk success criteria, against each measure. A high-level scoring system has been developed based on the guidance in the Environment Agency Flood and Coastal Flood Risk Management Appraisal Guidance and Defra SWMP Technical Guidance. The scoring criteria are provided in

4.2.5 Table 4-2.

Table 4-2 Options Assessment Short Listing Criteria

Criteria	Description	Score
Technical	• Is it technically possible and buildable? • Will it be robust and reliable? • Would it require the development of a new technique for its implementation?	U: Unacceptable (measure eliminated from further consideration) -2: Severe negative outcome -1: Moderate negative outcome 0: Neutral +1: Moderate positive outcome +2: High positive outcome
Economic	• Will benefits exceed costs? • Is the measure within the available budget? • Estimate the whole life costs of the option including asset replacement, operation and maintenance. The scoring of this measure will depend on the budget available from the local authority although it should be remembered that alternative routes of funding could be available such as Thames Region Flood Defence Committee.	
Social	• Will the community benefit or suffer from implementation of the measure? • Does the option promote social cohesion or provide an improved access to recreation/open space? • Does the option result in opposition from local communities for example if an option involves the displacement of houses?	
Environmental	• Will the environment benefit or suffer from implementation of the measure? • Would the option have a positive or negative effect on the environment for example, water quality and biodiversity?	
Objectives	• Will it help to achieve the objectives of the SWMP partnership? • Does the option meet the overall objective of alleviating flood risk?	

4.2.6 The results of the measures assessment is summarised in Table 4-3. Appendix B provides the short listed measures that have been identified for each Ward and the associated scoring criteria.

Table 4-3 Measures Opportunity Assessment

ID	Ward	Source								Pathway							Receptor				
		Green Roof	Soakaways	Swales	Permeable Paving	Rainwater Harvesting	Rain Gardens and Tree Planters	Detention Basins	Ponds and Wetlands	Increasing Capacity in Drainage Systems	Separation of Foul and Surface Water Sewers	Improved Maintenance Regimes	Managing Overland Flows (Online Storage)	Managing Overland Flows (Preferential Flow paths)	Land Management Practices	De-culverting Watercourse(s)	Improved Weather Warning	Planning Policies to Influence Development	Temporary or Demountable Flood Defences	Social Change, Education and Awareness	Improved Resilience and Resistance Measures
1	College Park and Old Oak	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
2	Wormholt and White City	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
3	Shepherd's Bush Green	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
4	Askew	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
5	Ravenscourt Park	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
6	Hammersmith Broadway	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
7	Addison	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
8	Avonmore and Brook Green	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
9	Fulham Reach	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
10	North End	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
11	Palace Riverside	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
12	Munster	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
13	Fulham Broadway	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
14	Town	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
15	Parsons Green and Walham	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
16	Sands End	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓

Measures Opportunity Assessment Criteria	
✓	There are opportunities for implementation of this mitigation measure within the Ward. Measure should be considered in the Options Assessment.
✓	There may be some, but limited opportunities for implementation of this mitigation measure within the Ward. Measures should be considered in the Options Assessment but would likely be limited in effectiveness or be subject to site-specific investigations prior to consideration.
×	There are no opportunities for implementation of the measure within the Ward. The measure is not suitable or required to address the surface water flood risk within the Ward.

Stage 3 Borough Wide Preferred Options

4.2.7 An Options Workshop was held with LBHF to discuss and agree the short listed options for the entire Borough as well as for each Ward through the options assessment. The process aimed to ensure that inappropriate measures were eliminated early in the process to avoid investigation of options that are not acceptable to stakeholders. The agreed short listed options have been progressed to the Preferred Options stage where they have been further developed.

4.2.8 The options assessment identified a number of structural and non-structural measures that are applicable across the majority of the Borough area. These were brought forwards as the preferred option due to their potential for wide scale implementation.

4.2.9 The structural measures have been individually incorporated into the baseline TUFLOW – ESTRY model to determine their potential impact on flood extent and depth in critical locations across the Borough. The modelled options have been run for a number of return period events to assess their potential impact for a variety of rainfall events. The structural measures include:

1) Tree Planters
2) Green Roofs
3) Permeable Paving
4) Detention Basins

4.2.10 The non-structural measures include:

5) Raising Community Awareness;
6) On-going Improvements to Maintenance of Drainage Network;
7) Planning and Development Policies;
8) Water Conservation; and,
9) Improving Resilience to Flooding.

Stage 4 Cost Benefit Analysis

4.2.11 A high level cost benefit analysis has been completed for each of the preferred structural options. A detailed appraisal of cost and benefits of each of the options is not deemed to be practical for the strategic level of this study and should be carried out as part of a more detailed cost: benefit appraisal for individual Wards and/or options, potentially as part of a feasibility study.

Benefits

4.2.12 The following factors have been used to determine the high level benefits for each preferred option:

- Estimated number of properties with reduced average flood depths;
- Estimated number of properties removed from a higher risk category[xii] to a lower risk category, and;

[xii] As defined by the Environment Agency FCRM GiA outcome measures: very significant risk = 5% AEP (1 in 20 years), significant risk = 1.3% AEP (1 in 75 years), moderate risk = 0.5% AEP (1 in 200 years)

- Qualitative assessment of additional environmental and social benefits.

Costs

4.2.13 An estimated cost for the preferred flood mitigation option has been calculated based on standard unit costs provided as part of Tier 1 of the Drain London Project. No monetised damages have been calculated, and flood mitigation costs have been determined using engineering judgement, but have not undergone detailed analysis. The following assumptions have been made to determine the costs for each option:

- The costs are estimated capital costs for implementation of the scheme and maintenance costs only;
- Costs do not include provisions for consultancy, design, supervision, planning process, permits, environmental assessment or optimum bias;
- No provision is made for weather (e.g. winter working);
- No provision is made for access constraints;
- Where required, it will be stated if costs include approximate land acquisition components;
- No operational costs are included; and,
- No provision is made for disposal of materials (e.g. for flood storage or soakaway clearance).

4.2.14 As a result, the capital costs and maintenance costs have been provided as cost bands[xiii], reflecting the strategic nature of the SWMP study and options identification.

4.2.15 Maintenance costs have been calculated based on estimates of maintenance requirements for the designed life of the schemes (all assumed to be 100 years). These have been converted to 'present values' in accordance with FCERM Guidance and are intended to reflect the total value of all future costs and benefits at today's process. A discount rate of 3.5% in year 0 to 30, 3% in year 31 to 75 and 2.5% in year 76 to 99 as currently set by the Treasury.

4.3 Preferred Options

4.3.1 The preferred options have been identified through Stages 1 – 4 of the Options Assessment and are discussed in further detail within this Section.

LBHF Wide Preferred Options

4.3.2 The Options Assessment identified a number of structural and non-structural measures that were common to all Wards, and should be considered across the LBHF administrative area. The Council and relevant stakeholders may consider adopting these as part of their responsibility as LLFA for local flood risk management.

[xiii] As defined by Drain London Prioritisation Matrix Guidance, the cost bands to be used are: <£25k, £26k - £50k, £51k - £100k, £101k - £250k, £251k - £500k, £501k - £1m, £1m - £10m and >£10m.

Borough Wide Option: Tree Planters (Structural measure 1)

Within the LBHF there are approximately 16,000 trees recorded on the council's database. Of these approximately 3,300 (20%) are located within park areas and 12,700 (80%) are located along roadsides within residential land or commercial areas.

This option has been selected to examined the potential impact of taking all of the trees within the Borough, excluding those already in parks, and modifying their planted area to allow for surface water to flow from the roads towards the trees, instead of being directed to the gullies. The option also considers increasing the planting area of the trees to allow for a larger permeable area at the base of the tree.

In practice, this would involve restructuring the planted areas around the tree to be at the same level as the road, with a porous surface. In practice, these could be combined into rain garden features, where additional planting is incorporated. Consideration would need to be given to the pollutant loading entering the planter system which could be managed through the inclusion of suitable substrates.

The planted area around trees can be modified to create biodiverse green areas, which could greatly enhance streetscapes. Where space is a limiting factor, the planted area could be simply covered by a grate which would cause less disruption and still allow for increased infiltration of surface water runoff.

This option has been modelled by reducing the ground elevation to equal the road level (i.e. to be below pavement level), increasing the infiltration potential, and increasing the roughness. It has been assumed that each tree has a planter area of $3m^2$ (equivalent to 1 grid cell within the model). The combined effect of the tree planters is to attenuate surface water, predominantly from overland flow, within the tree area, thus reducing the volume of water entering the drainage network.

Figures 4.3-1 outlines the results for the model run incorporating this option and the reduction in maximum surface water flood depth in comparison to the baseline run for the 5% AEP event. Appendix A details locations of the modelled tree pits and the results for the 10% AEP, 1.3% AEP and 1% AEP model runs.

Figure 4.3-1 – Tree Planter Option 5% AEP Depth and Areas of Betterment

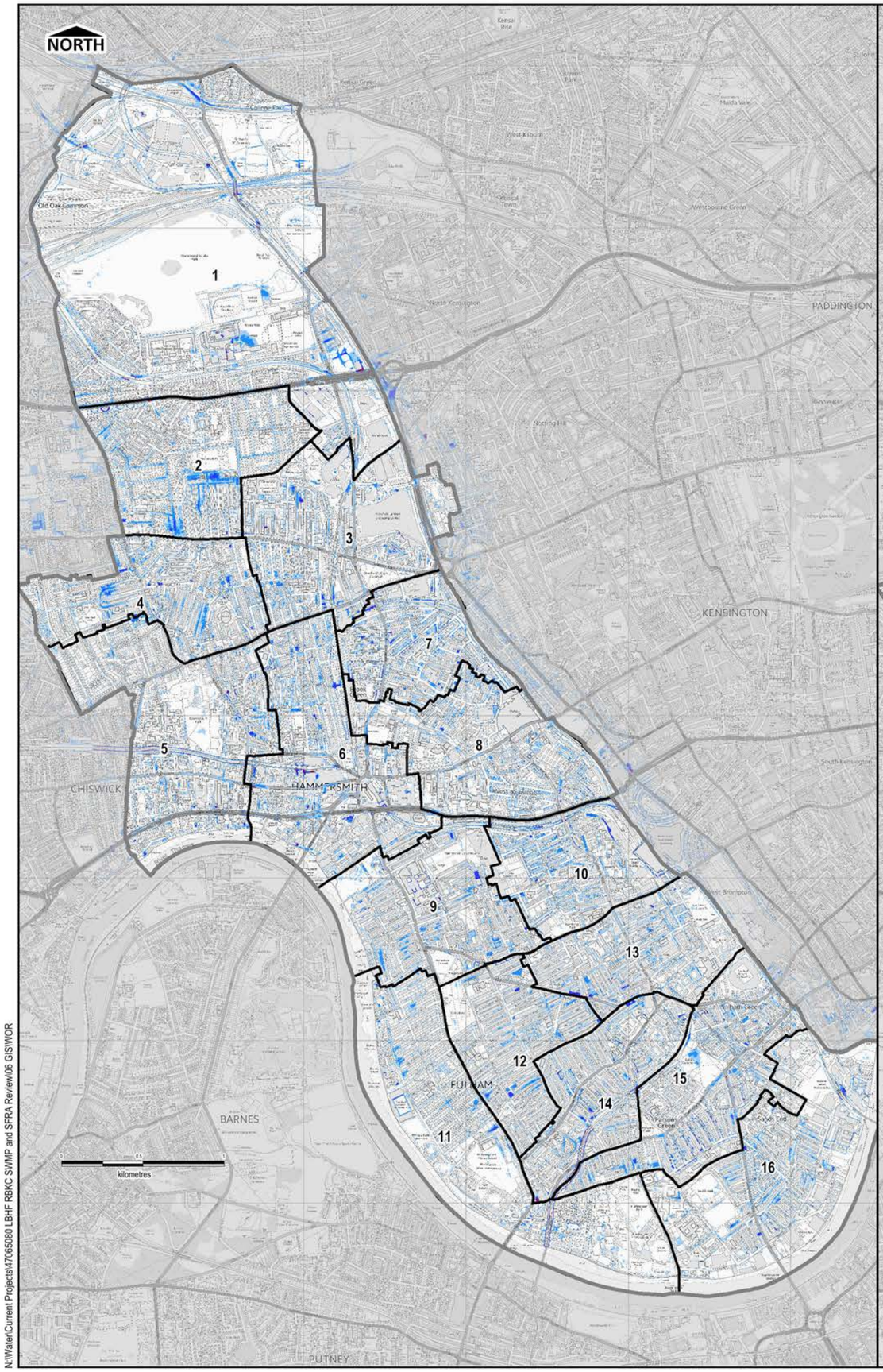
Benefits

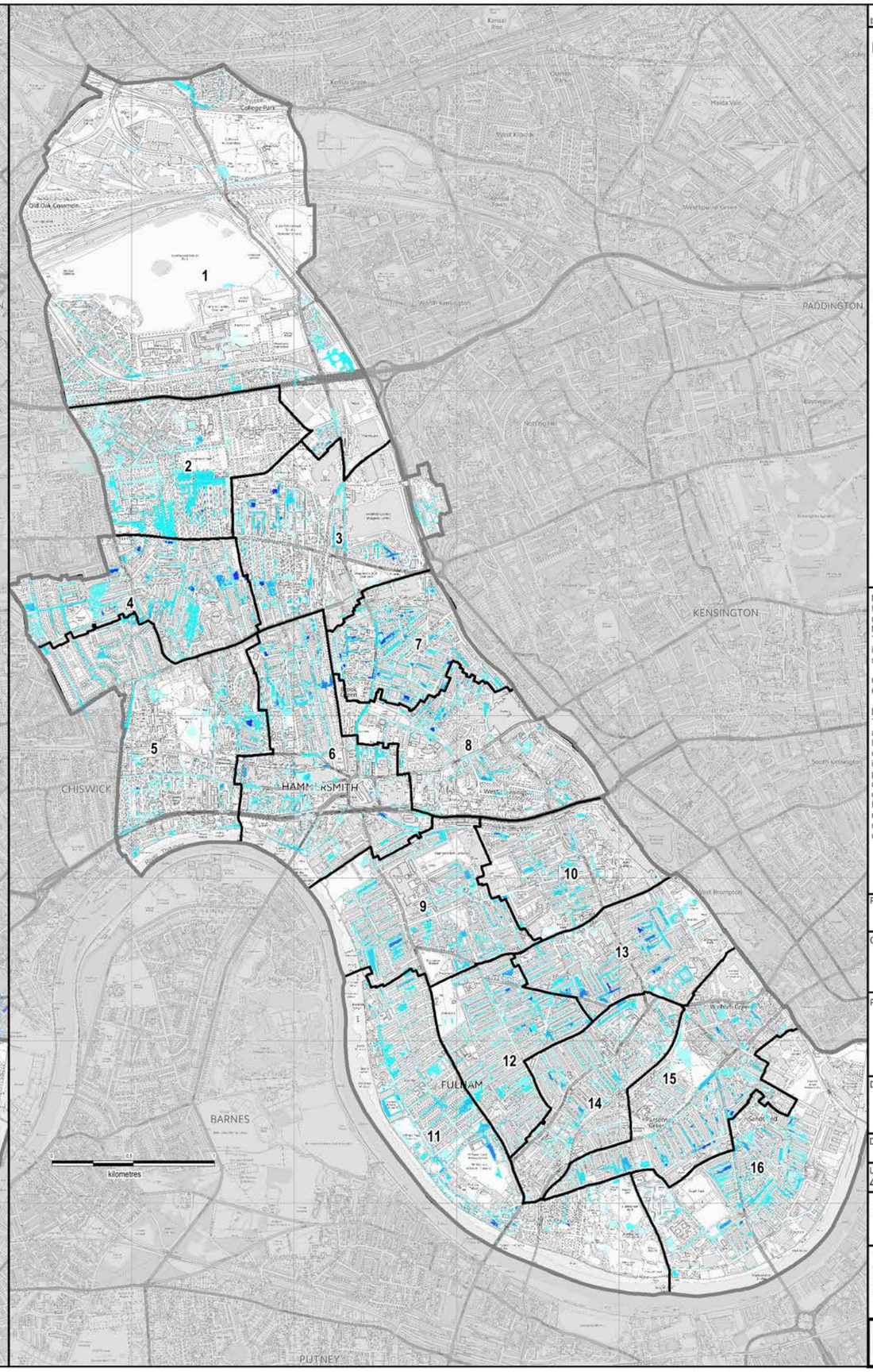
Surface Water Management

The extensive incorporation of tree planters across the Borough results in a reduction in the maximum flood depths experienced in many locations. The greatest attenuation achieved is seen in the tree planters located alongside roads rather than in open spaces. This is due to the roads acting to direct flow which coincides with the trees planted alongside.

Figure 4.3-1 presents the change in maximum flood depth during the 5% AEP rainfall event and identifies that the installation of tree planters has a widespread positive effect on maximum flood depths throughout the Borough. The Wards of Wormholt and White City, Askew, Avonmore and Brook Green, Fulham Reach, Munster and Sands End benefit considerable from the proposed measures.

Across the different modelled AEP rainfall events, the impact of the tree planters is most noticeable during the 1.33 AEP (1 in 75 year) rainfall event.





THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT

LEGEND

- LBHF Administrative Boundary
- Ward Boundary

Surface Water Flood Depth (m)

- < 0.1m
- 0.1 - 0.25m
- 0.25 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- > 1.5m

Reduction in maximum flood depth (m)

(Calculated from 'Option Depth minus Baseline Depth')

- -0.1m
- -0.01m
- 0 (No Change)

Ward Names
1 - College Park and Old Oak
2 - Wormholt and White City
3 - Shepherd's Bush Green
4 - Askew
5 - Ravenscourt Park
6 - Hammersmith Broadway
7 - Addison
8 - Avonmore and Brook Green
9 - Fulham Reach
10 - North End
11 - Palace Riverside
12 - Munster
13 - Fulham Broadway
14 - Town
15 - Parsons Green and Walham
16 - Sands End

NOTES
Hydraulic modelling has been undertaken using linked 2D-1D hydraulic modelling software TUFLOW-ESTRY (ver 2012). Refer to the LBHF Model Build Report (2015) for further information on model limitations. The intended purpose of this drawing is to illustrate flood depth in areas in excess of 81m2. Due to the coarse nature of the data the results should not be used to examine flooding at property level.

Purpose of Issue: FINAL

Client: h&f hammersmith & fulham

Project Title: LONDON BOROUGH OF HAMMERSMITH AND FULHAM UPDATED SURFACE WATER MANAGEMENT PLAN

Drawing Title: OPTION 1: TREE PLANTERS FLOOD DEPTH AND AREAS OF BETTERMENT (5% AEP)

Drawn	Checked	Approved	Date
SL	MI	MT	08/04/2015

URS Internal Project No.	Scale at A3
47065080	1:95,000

URS Infrastructure & Environment UK Limited
6 - 8 Greencoat Place
London
SW1P 1PL
Telephone +44 (0)207 7985000
CAPITA URS Flood Risk Management

Drawing Number: FIGURE 4.3-1

Rev: 2

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Property Counts

The options modelling indicates, that for the installation of tree planters across the Borough, the effect on flooded property counts are as follows:

- 4124 residential properties and 543 non-residential properties across the Borough are modelled to experience flood depths of >0.1m during the 5% AEP rainfall event. This is a reduction of 444 properties across the borough in comparison to the baseline scenario.
- 199 residential properties and 28 non-residential properties across the Borough are modelled to experience flood depths of >0.5m during the 5% AEP rainfall event. This is a reduction of 43 properties across the borough in comparison to the baseline scenario.

Additional Benefits

The provision of tree planters would have additional environmental and social benefits including enhanced aesthetics of the urban environment and provision for biodiversity, as well as air quality improvements and mitigation of the urban heat island effect. These factors could be further enhanced through the planting of additional trees using bio-filtration systems that further act to remove pollutants from surface water runoff therefore providing water quality improvements.

Costs

To modify the planter areas around existing trees, it has been estimated to cost between £500 - £1,000 per tree unit based on costs provided by LBHF. This estimate includes the excavation works and provision of additional substrate and covering. To apply this to all of the trees within the Borough, the cost would be in the price band of >£10m.

To plant new trees, with specialised bio retention substrates, it is estimated to cost between £500 - £1,000 per tree unit.

Maintenance requirements for tree planter systems would include the regular clearing of debris. Bio retention systems additionally require the periodic replacement of the plant growth substrate in order to maintain the water quality functions. It has been estimated that the present value for the maintenance of each tree every 10 years over a 100 year lifetime would be approximately £150 - £200 per tree unit.

Recommendation 10: Consider and implement options for installation of tree planters across the Borough and the utilisation of space around existing trees.	
Option A:	The implementation of modified tree planting areas could be phased in across the Borough. As road and pavement improvement works are undertaken, the adjustment of road levels and pavement areas could be modified to provide an increased area of storage for each tree. As shown in the modelling, the existing surface water flow paths are predominantly determined by the layout of the road. The initial prioritisation could therefore be given to trees planted adjacent to roads to intercept these flows.
Option B:	Plant additional trees across the Borough to incorporate the surface water management objectives. The use of bio retention systems could also be incorporated to provide addition water quality improvements. Coordinate with the LBHF Parks department to implement these systems.

Borough Wide Option: Green Roofs (Structural measure 2)

This measure would see the development of green roof systems by retrofitting the roofs of suitable council owned buildings. As outlined in Section 5 of the LBHF Water Management Policy (2013), the use of flat roofed council owned buildings for retrofitting of green roofs should be considered.

Green roofs are roofs that are predominantly covered with vegetation and a growing medium. They function as source control measures that retain and attenuate rainfall falling on the roof area. The retention and attenuation potential of green roofs depend largely on their type. In general, it can be assumed that the greater the volume of substrate making up the green roof, the greater attenuation and retention provided.

A broad scale assessment of suitable roof areas had been completed by LBHF. This found a total area of 12.7 hectares to be suitable for the retrofitting of green roof systems. It should be noted that this assessment included a broad assessment of structural capacity of roof areas for the additional weight of green roofs; however, if any schemes are to be taken forward, full structural surveys of roof areas would be required.

Green roofs have been represented within the modelling through the application of an initial rainfall loss. As shown in Figure A-15a, the green roofs are located across most of the Wards, with the exception of Wormholt and White City and Munster. As described above, there are a wide variety of green roof systems. The option modelled has assumed the application of an extensive green roof with a substrate depth of 100mm. It is assumed that a typical green roof can hold a volume of water equivalent to 10% of the substrate depth. Therefore, in this scenario, that would imply 10mm of water retained.

The inclusion of green roof systems would see a greater retention of rainfall at the source resulting in a reduction in the volume of water flowing from the roof areas to the drainage network and surrounding land.

Figure 4.3-2 outlines the results for the model run incorporating this option, and the reduction in maximum flood depth between the baseline run and options run for the 5% AEP event. Figures A-15a to A-15d (in Appendix A) identify the locations of the modelled green roof locations and the results of the 10% AEP, 1.3% AEP and 1% AEP model runs.

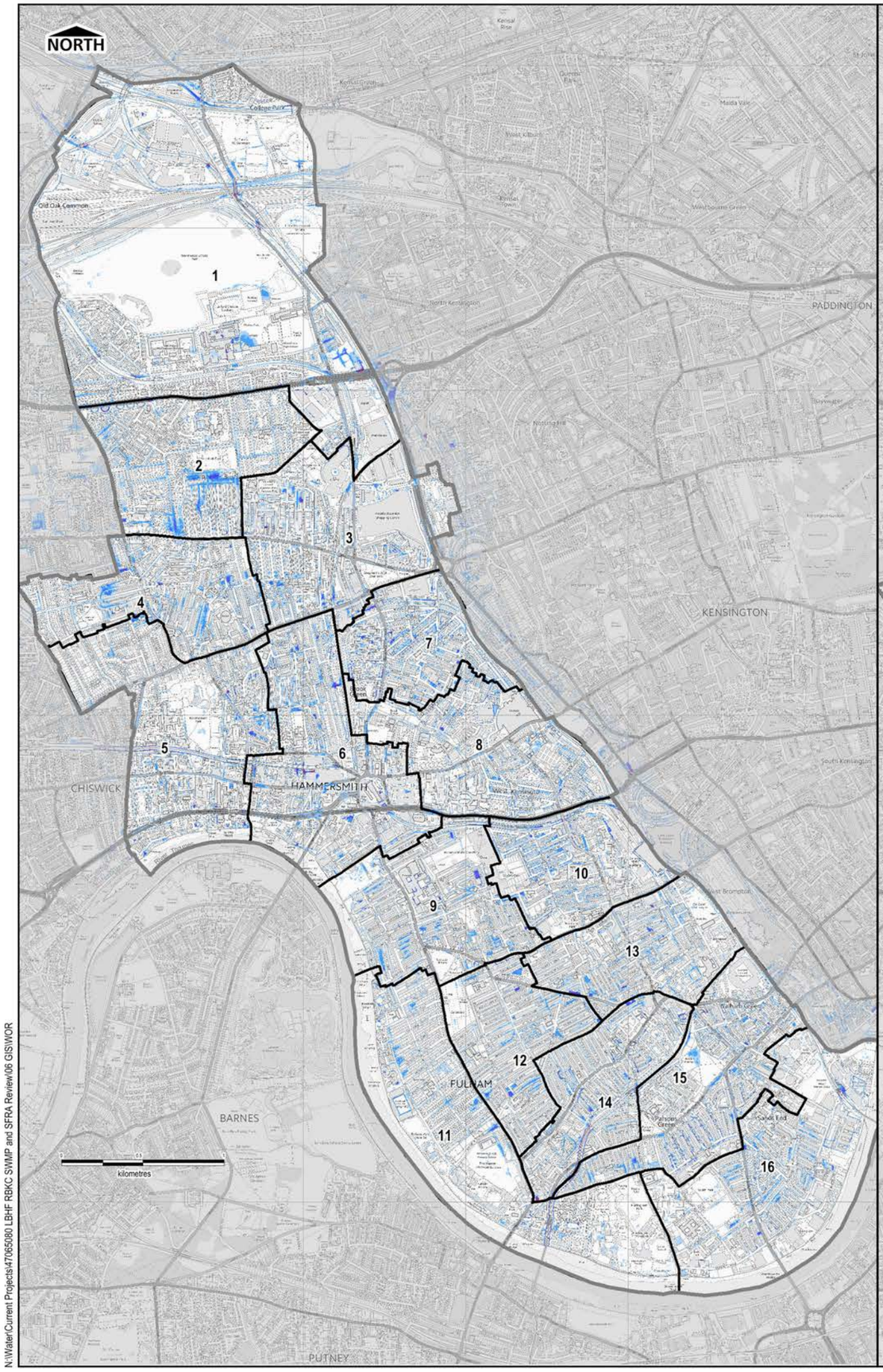
Figure 4.3-2 – Green Roof Option 5% AEP Depth and Areas of Betterment

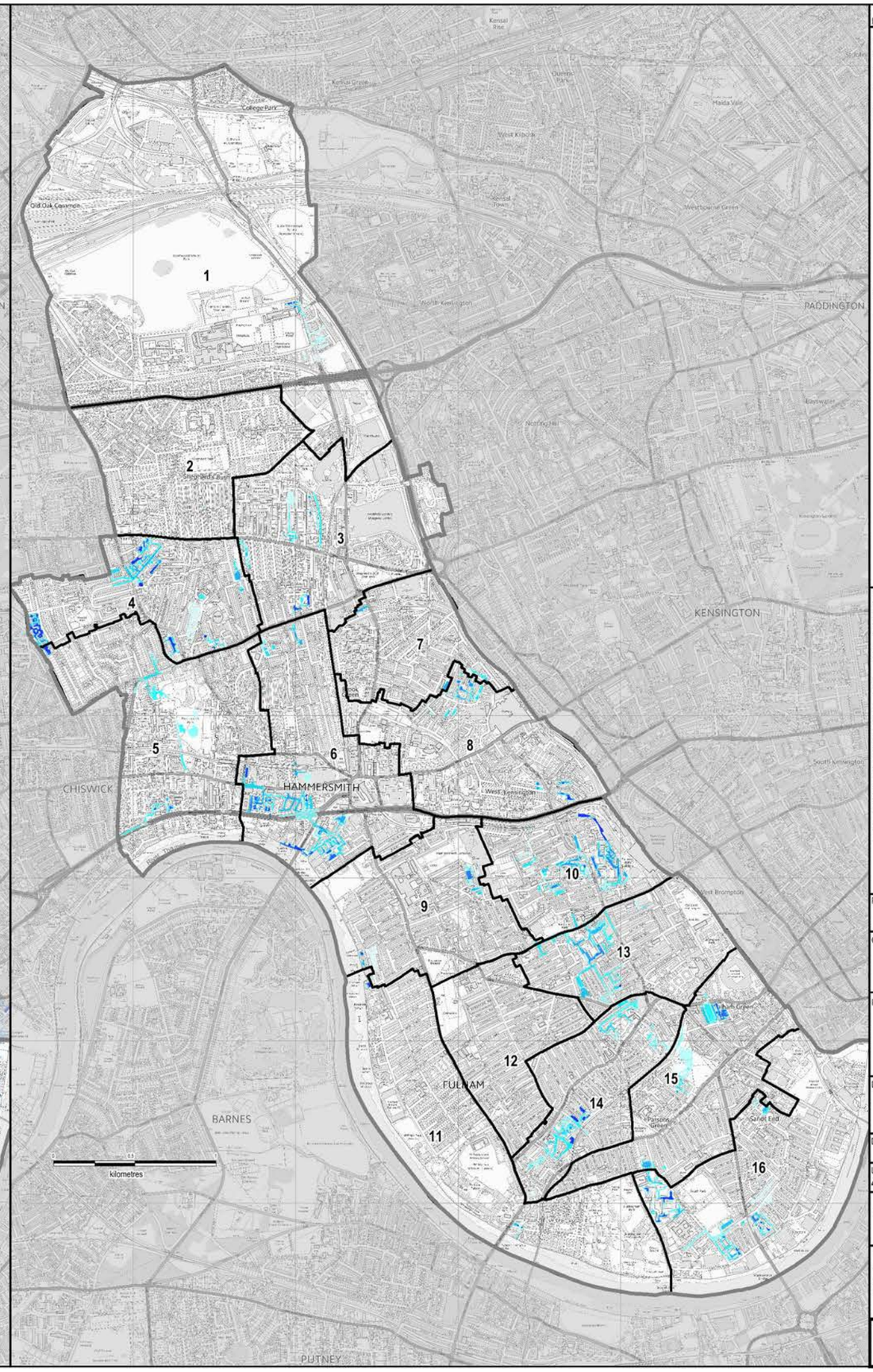
Benefits

Surface Water Management

Green roofs are well known for the wide range of environmental benefits they offer. This includes improvements in air quality, water quality, ecology, amenity, aesthetics and noise insulation in addition to their rainfall runoff functions.

Figure 4.3-2 shows the impact of the installation of green roofs across the selected council-owned buildings. The figure shows that the inclusion of the green roofs reduces the maximum surface water flood depths experienced in a number of areas; however the betterment is relatively minor. During the 5% AEP rainfall event, reductions in maximum flood depths of in the region of 0.01m are experienced in those areas in which green roofs are located. Areas impacted include Askew, either side of the A4 in Hammersmith Broadway, North End around the exhibition centre, Fulham Broadway, Town and Sands End. The benefit that the green roofs provide in terms of reduction in maximum flood depths and area





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LEGEND

LBHF Administrative Boundary

Ward Boundary

Surface Water Flood Depth (m)

- < 0.1m
- 0.1 - 0.25m
- 0.25 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- > 1.5m

Reduction in maximum flood depth (m)

(Calculated from 'Option Depth minus Baseline Depth')

- -0.1m
- -0.01m
- 0 (No Change)

Ward Names

1 - College Park and Old Oak
2 - Wormholt and White City
3 - Shepherd's Bush Green
4 - Askew
5 - Ravenscourt Park
6 - Hammersmith Broadway
7 - Addison
8 - Avonmore and Brook Green
9 - Fulham Reach
10 - North End
11 - Palace Riverside
12 - Munster
13 - Fulham Broadway
14 - Town
15 - Parsons Green and Walham
16 - Sands End

NOTES

Hydraulic modelling has been undertaken using linked 2D-1D hydraulic modelling software TUFLOW-ESTRY (ver 2012). Refer to the LBHF Model Build Report (2015) for further information on model limitations. The intended purpose of this drawing is to illustrate flood depth in areas in excess of 81m2. Due to the coarse nature of the data the results should not be used to examine flooding at property level.

Purpose of Issue: FINAL

Client: h&f hammersmith & fulham

Project Title: LONDON BOROUGH OF HAMMERSMITH AND FULHAM UPDATED SURFACE WATER MANAGEMENT PLAN

Drawing Title: OPTION 2: GREEN ROOFS FLOOD DEPTH AND AREAS OF BETTERMENT (5% AEP)

Drawn	Checked	Approved	Date
SL	MI	MT	08/04/2015

URS Internal Project No.: 47065080

Scale at A3: 1:95,000

URS Infrastructure & Environment UK Limited
6 - 8 Greencoat Place
London
SW1P 1PL
Telephone +44 (0)207 7985000

CAPITA URS Flood Risk Management

Drawing Number: FIGURE 4.3-2

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shown to benefit increases slightly for the greater magnitude return period events.

The benefits that green roofs provide in terms of surface water management are minor and tend to be local to the green roof systems. The quantity of water retained with the green roof is largely dependent on the type of roof system and depth of substrate. Even once saturated, the increased surface roughness of the green roof will assist in reducing the runoff rate of surface water from the roof systems. The method used to model the green roof systems has made a great deal of assumptions about roof type and storage potential. The actual storage capability of green roof should be assessed on a site by site basis.

Property Counts

The options modelling indicates, that for the installation of green roofs on selected buildings across the Borough, the effects on flooded property counts are as follows:

- 4286 residential properties and 545 non-residential properties across the Borough are modelled to experience flood depths of >0.1m during the 1% AEP rainfall event. This results in a net reduction of flood risk to 280 properties across the borough in comparison to the baseline scenario.
- 195 residential property and 27 non-residential properties across the Borough are modelled to flood to a depth of >0.5m during the 1% AEP rainfall event. This equates to reduced flood risk for 48 properties compared to the baseline scenario.

Additional Benefits

Green roofs can provide a wide range of additional environmental and social benefits. Although largely dependent on the type of green roof, they can provide habitat and the potential for increased biodiversity. The plants within the green roof act to remove pollutants from the air, therefore providing air quality benefits. Green roofs can also help in reducing the urban heat island effect.

Green roofs are also known to provide benefits to the building itself, including reduction in noise transfer, cooling, and an increase in the lifespan of the roof. They can also be used to provide amenity space for access and as a marketing tool providing space for companies to entertain. Examples of this are apparent at major retailers on London's Oxford Street.

Costs

The indicative cost of a semi-intensive green roof unit is estimated to be approximately £140 / m^2 (GLA, 2008). This cost includes waterproofing and insulation costs. Therefore for implementation across the entire suitable roof area of 12.7 ha would be estimated to cost >£10m.

Maintenance requirements for green roof systems would include the biannual inspections of drainage outlets, removal of unwanted plants and application of fertilisers. It has been estimated that the present value for the maintenance of a green roof system across all the suitable roofs, for a 100 year lifespan, would be approximately £1m - £10m.

Recommendation 11: Consider installation of green roofs on a site by site basis for suitable council buildings, taking advantage of current feasibility investigations.

Option A:	Retrofit green roofs on suitable council buildings as identified the Councils preliminary green roof study. The feasibility of different types of green roof should be considered. As discussed above, green roof systems that are developed on a thicker substrate can offer a larger storm water retention volume. A detailed cost benefit analysis should also monetise the wide range of additional environmental advantages offered by green roofs: ecology, air quality etc.

Option B:	The policies within the Local Plan should be reviewed to highlight the Council's preference for installation of green roofs on new developments where it is suitable.

Borough Wide Option: Permeable Paving (Structural measure 3)

This option looks at the replacement of hardstanding surfaces in council owned open space with permeable paving.

Permeable paving is a source control measure that allows rainfall and surface water runoff to infiltrate through the paving to either the ground or to a drainage network. The mechanism of draining the paving is determined mainly by the geology of the underlying ground. There are many types of permeable paving that can be implemented based on the land use of the area.

Examination of the Ordnance Survey data and council owned land datasets indicates that there is potentially 23 ha of man-made ground that falls within the boundaries of council owned land. These areas have been incorporated into the model with modified parameters to simulate the storage and infiltration rates typical of permeable paving systems. These areas are located throughout the Wards in the borough, with the exception of Addison and Town (refer to Figure A-16a in Appendix A).

Technical specifications indicate that permeable paving can infiltrate at a rate of up to 5m/hour and has a void ratio of up to 40%. Assuming there is 0.5m of depth paving material (including substrates structures), this allows for up to 0.2m of storage. In order to accommodate this into the model, the infiltration rate has been adjusted to allow to 0.2m to be retained with the substrate. This equates to an infiltration rate of 0.06m/hour for the 3 hour model run.

The method used to simulate the effect of the permeable paving makes a large assumption about how the systems are drained. It should be noted that much of the Borough is located in areas where the drainage of permeable paving by infiltration would not be possible due to the presence of impermeable London Clay. Alternative solutions, such as drained systems could however be incorporated. In these instances, the hydrological function of the permeable paving would be to attenuate the peak flow of surface water runoff to the drainage network, therefore assisting with reducing the volumes of water within the sewer network at the peak of the event.

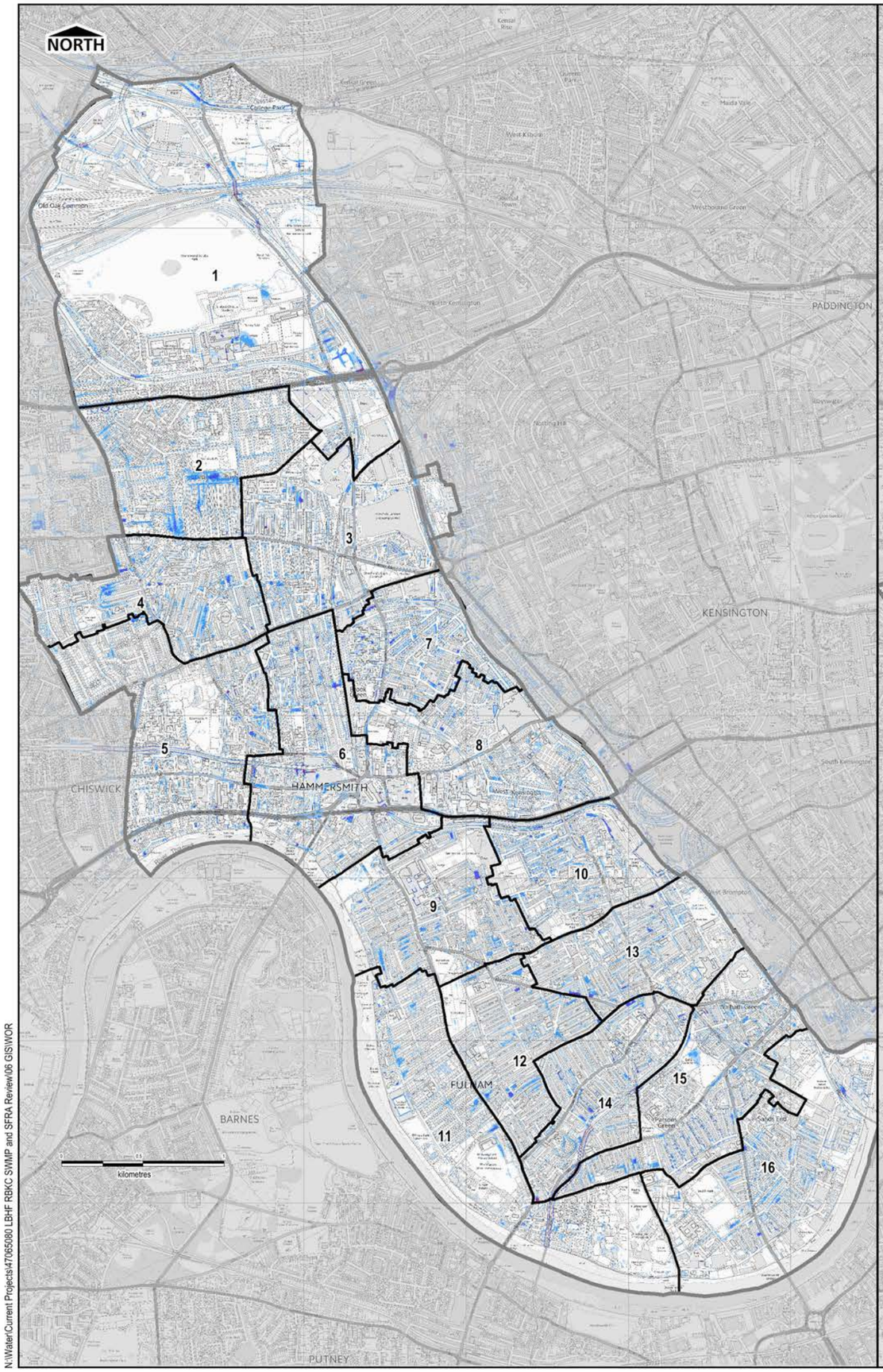
The extent of council owned open space within the Borough is minor. Incorporation of requirements for permeable paving within planning will help to ensure that new developments help to increase the total impermeable area. In addition, educational measures and public awareness can be implemented to encourage land owners to replace hardstanding surface with impermeable alternatives as and when they undertake works.

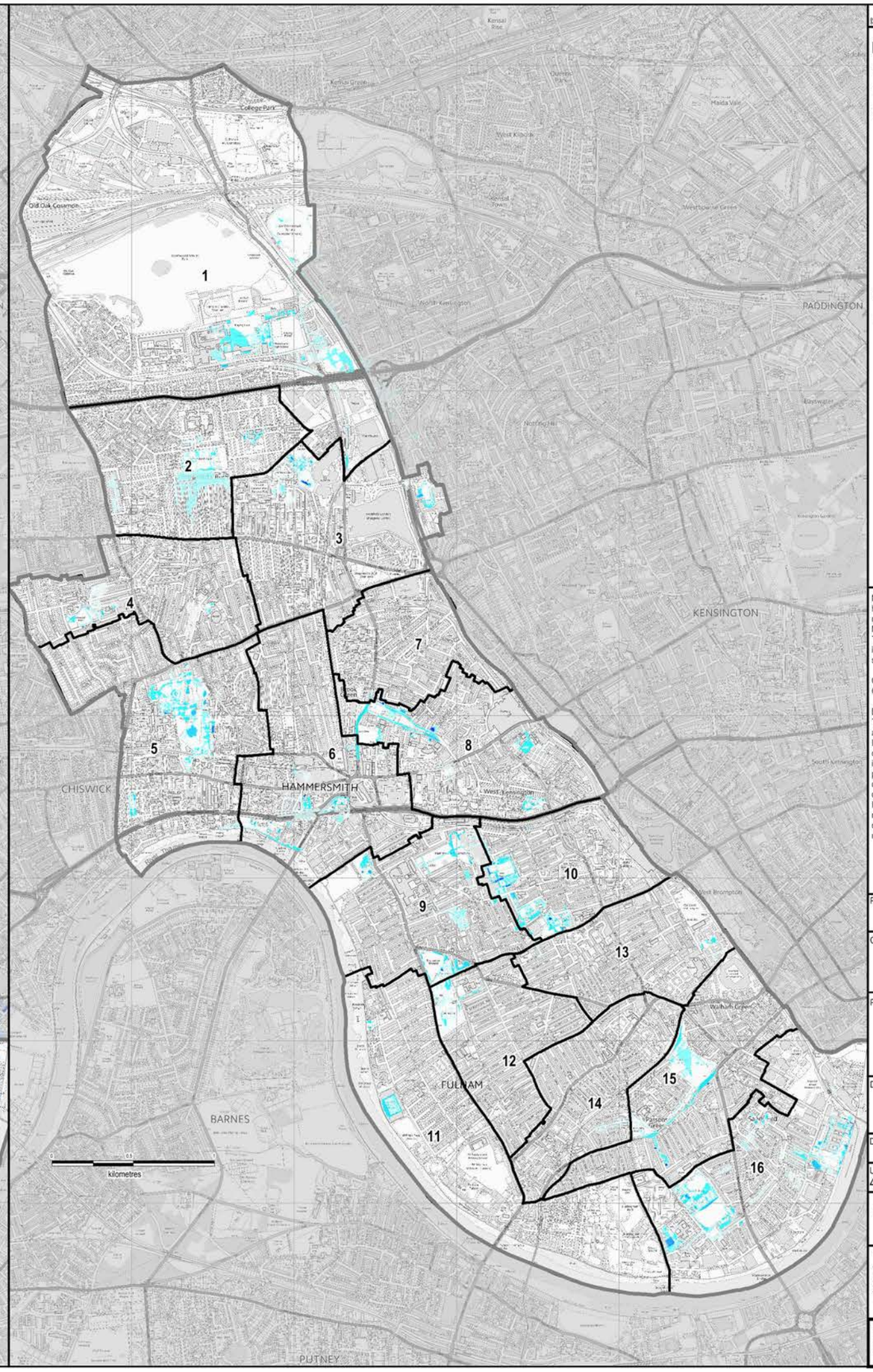
Figure 4.3-3 outlines the results for the model run incorporating this option, and the reduction in maximum flood depth between the baseline run and options run for the 5% AEP event. Appendix A details locations of the modelled permeable paving and the results of the 10% AEP, 1.3% AEP and 1% AEP model runs.

Figure 4.3-3 Permeable Paving Option 5% AEP Depth and Areas of Betterment

Paved Gardens

Impermeable paving in gardens can significantly increase surface water runoff entering the local drainage network. From the 1st October 2008 the permitted development rights that allow householders to pave their front garden with hard standing without planning permission was removed. Residents





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LEGEND

LBHF Administrative Boundary

Ward Boundary

Surface Water Flood Depth (m)

- < 0.1m
- 0.1 - 0.25m
- 0.25 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- > 1.5m

Reduction in maximum flood depth (m)

(Calculated from 'Option Depth minus Baseline Depth')

- -0.1m
- -0.01m
- 0 (No Change)

Ward Names

1 - College Park and Old Oak
2 - Wormholt and White City
3 - Shepherd's Bush Green
4 - Askew
5 - Ravenscourt Park
6 - Hammersmith Broadway
7 - Addison
8 - Avonmore and Brook Green
9 - Fulham Reach
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13 - Fulham Broadway
14 - Town
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NOTES

Hydraulic modelling has been undertaken using linked 2D-1D hydraulic modelling software TUFLOW-ESTRY (ver 2012). Refer to the LBHF Model Build Report (2015) for further information on model limitations. The intended purpose of this drawing is to illustrate flood depth in areas in excess of 81m2. Due to the coarse nature of the data the results should not be used to examine flooding at property level.

Purpose of Issue: FINAL

Client: h&f hammersmith & fulham

Project Title: LONDON BOROUGH OF HAMMERSMITH AND FULHAM UPDATED SURFACE WATER MANAGEMENT PLAN

Drawing Title: OPTION 3: PREMEABLE PAVING FLOOD DEPTH AND AREAS OF BETTERMENT (5% AEP)

Drawn	Checked	Approved	Date
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URS Internal Project No.	Scale at A3
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URS Infrastructure & Environment UK Limited
6 - 8 Greencoat Place
London
SW1P 1PL
Telephone +44 (0)207 7985000

CAPITA URS Flood Risk Management

Drawing Number: FIGURE 4.3-3

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should be encouraged to design their gardens in a way that optimises drainage and reduces runoff. The Council should publicise this issue and refer to standard guidance on the surfacing of front gardens provided by the Communities and Local Government and Environment Agency in September 2008.

Benefits

Surface Water Management

Figure 4.3-3 shows the change in maximum flood depth during the 5% AEP rainfall event and identifies that the installation of permeable paving results in small but widespread reductions in maximum surface water flood depths throughout the borough. Areas identified to benefit include Hammersmith Hospital in College Park and Old Oak; Sawley Road and Dunraven Road in Wormholt and White City; Ravenscourt Park; the road network in Hammersmith Broadway; the parallel roads of Brook Green; and New King's Road in Parsons Green. In general, flood depths are modelled to reduce by up to 0.1m during the 5% AEP rainfall event.

Across the different modelled AEP rainfall events, the impact of the permeable paving is quite similar. During the 1.33% AEP and 1% AEP events, the extent of flooding is greater, and therefore the areas shown to benefit are also extended, however the magnitude of flood depth reduction remains similar across the different modelled rainfall events.

Property Counts

The options modelling indicates, that for the permeable paving within the selected areas across the Borough, the effect on flooded property counts are as follows:

- 4197 residential properties and 547 non-residential properties across the Borough are modelled to experience flood depths of >0.1m during the 5% AEP rainfall event. This is a reduction of 367 properties across the borough in comparison to the baseline scenario.
- 203 residential properties and 29 non-residential across the Borough are modelled to experience flood depths of >0.5m during the 5% AEP rainfall event. This is a reduction of 38 properties across the borough in comparison to the baseline scenario.

Additional benefits

In addition to the surface water runoff benefits provided by permeable paving, the systems offer additional water quality benefits as a large number of pollutants found within urban runoff is removed through filtration though the paving mediums.

Costs

The cost of installing permeable paving is estimated to be approximately £44 / m^2 of surface area (CIRIA SuDS Manual, 2007). Therefore for implementation across the entire suitable area would be estimated to cost >£10m.

Maintenance is required to ensure the performance of these systems is not reduced. The use of grit and salt during winter months may adversely affect the drainage potential of certain permeable surfaces. Maintenance requirements for permeable paving would potentially include the periodical jet washing of the paving system to unclog pores and retain the systems porosity. It has been estimated that the present value for the maintenance of permeable paving across the entire suitable area, for a 100 year lifespan, would be approximately £51k - £100k.

Recommendation 12: Consider installation of permeable paving across council owned open spaces through the review of the site maintenance regime and refurbishment programmes.

Option A:	The installation of permeable paving systems through the gradual replacement of hardstanding surfaces with permeable paving options. This could be done through the review of the council's maintenance regime to identify which areas require resurfacing or other maintenance activities. When works are due to be undertaken in suitable areas, the opportunity to replace hard standing surfaces with permeable options should be used.
Option B:	The council could aim to raise awareness of the options for installation and maintenance of permeable surfaces within property grounds of residents and landowners.
Option C:	The council could aim to provide an information portal that residents can consult for further information on existing planning regulations, guidance and best practice, including links to other organisations (e.g. Environment Agency and Susdrain) who can provide 'best practice' guidance and examples.

Borough Wide Option: Flood Storage (Structural measure 4)

Three flood storage options have been modelled within parks in the upper parts of the model catchment. The flood storage options have been modelled as either flood storage basins or flood storage bunds. These both function to temporarily store surface water runoff from the contributing area.

Flood storage basins are typically designed to be multifunctional in that they remain free of water under dry conditions. These may form areas of public open space or recreational areas. During a rainfall event, they retain water and discharge it to the drainage network at a reduced rate. Alternatively storage basins can be developed into wetlands or ponds, allowing for greater habitat and biodiversity provision.

Basins also provide areas for treatment of water by settlement of solids in ponded water and the absorption of pollutants by aquatic vegetation or biological activity. The construction of basins uses relatively simple techniques. Local varieties of vegetation should be used wherever possible and should be fully established before the basins are used. Access to the basin should be provided so that inspection and maintenance is not restricted. This may include inspections, regular cutting of grass, annual clearance of aquatic vegetation and silt removal as required.

Flood storage bunds are an alternative approach to retaining flood waters. These are developed to act as a barrier to the flow of surface water, allowing for the water to pond behind the bund.

A number of detention basins and flood storage bunds have been modelled within the upper part of the catchment (the north and north west of the Borough). This is intended to provide an overview of the impact of a few, larger schemes on critical flooding areas.

Detention basins have been modelled indicatively through the adjustment of the model topography. This has also been applied to adjacent roads to ensure that surface water is directed to the detention basin. The modelled options include:

- **Wormwood Scrubs and Old Oak Common:** There is a tendency for surface water to flow off the higher ground of Wormwood Scrubs in College Park and Old Oak. Therefore, an option would be to intercept these flows and so prevent the runoff of surface water to the more vulnerable residential and commercial areas to the south. This could be accomplished through the creation of a detention basin or flood storage bunds along the southern extent of Wormwood Scrubs and Old Oak Common. These would act to intercept the main flow paths runoff off the park area to the north of the Linford Christie Stadium, HM Wormwood Scrubs Prison and to the north of Braybrook Street.
- **Wormholt Park:** In order to reduce the extent and depth of the flooding along Sawley Road to the south of Wormholt Park in Wormholt and White City, there may be opportunity to re-landscape the southern part of the park to provide flood storage. This would also require the contouring of the road adjacent, to encourage the flow of water into the park.

- **Wendell Park:** The baseline model results show a tendency for surface water to flow towards the residential areas of Becklow Road, Cobbold Road and Gayford Road in Askew. The flood depths within this area are significant. The option would be for the development of a flood storage area within Wendell Park, as this is adjacent to the main flow routes along Cobbold Road. This option would include the contouring of the park and the road to allow for surface water to accumulate within the park during extreme rainfall events.

Figure 4.3-4 outlines the results for the model run incorporating this option, and the reduction in maximum flood depth between the baseline run and options run for the 5% AEP event. Appendix A details locations of the modelled flood storage area locations and the result of the 10% AEP, 1.3% AEP and 1% AEP model runs.

Figure 4.3-4 Flood Storage Option 5% AEP Depth and Areas of Betterment

Benefits

Surface Water Management

Figure 4.3-4 highlights that the implementation of the above mentioned flood storage areas has a notable effect on flood depths.

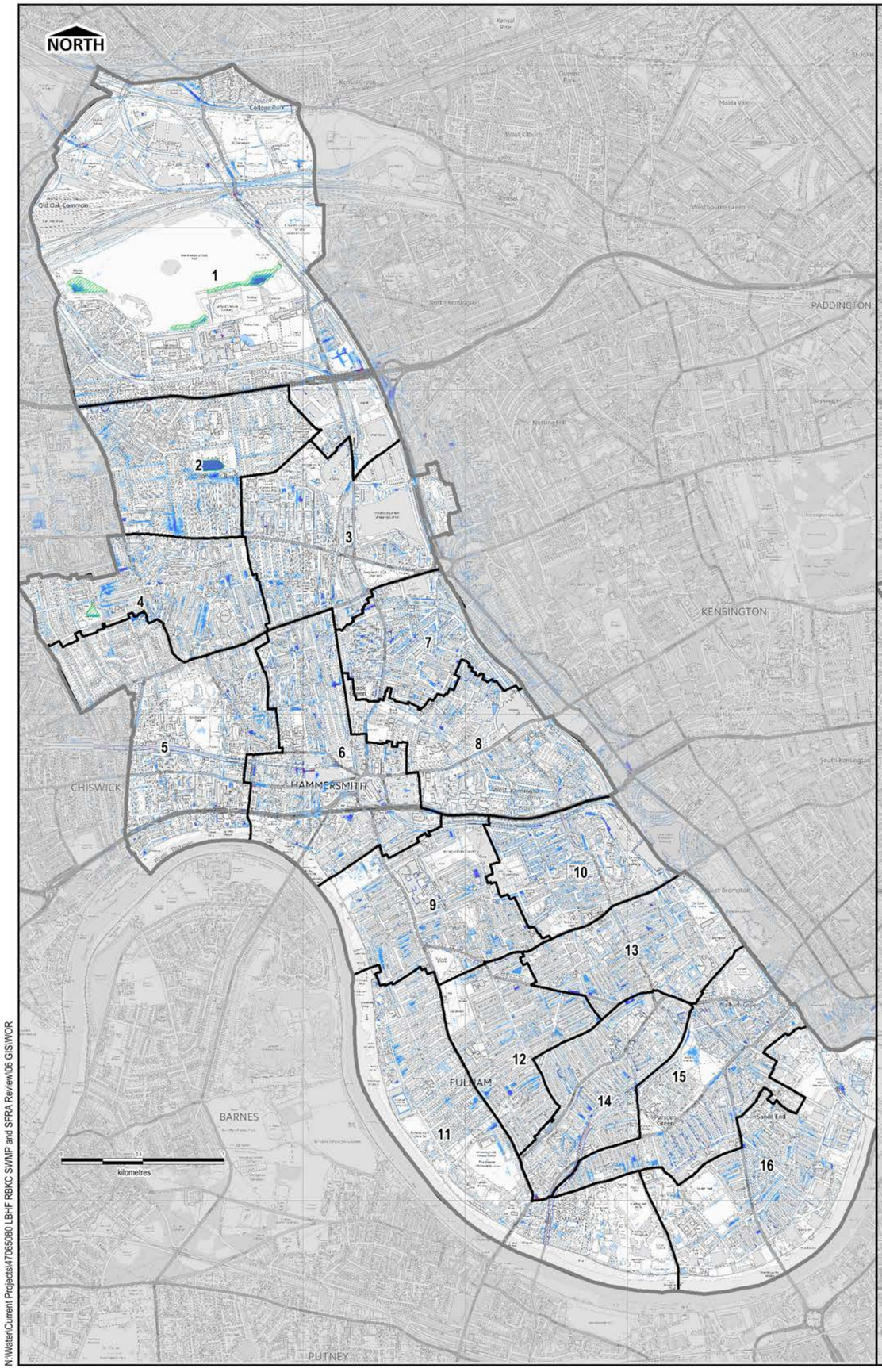
Wormwood Scrubs and Old Oak Common: Three flood storage bunds have been modelled within the Wormwood Scrubs area. During the 5% AEP modelled rainfall event, these 3 storage areas have been modelled to collectively retain approximately 5,800m^3 of surface water runoff that has been intercepted from the Wormwood Scrubs area. This has a significant effect on the flood depths downstream, with the most notable benefit of a 0.1-0.15m reduction in flood depths within the area of the Hammersmith Hospital. Further to the west, the flood storage bund shows a reduction in flood depths of up to 0.15m along Wulfstan Street for the same return period event.

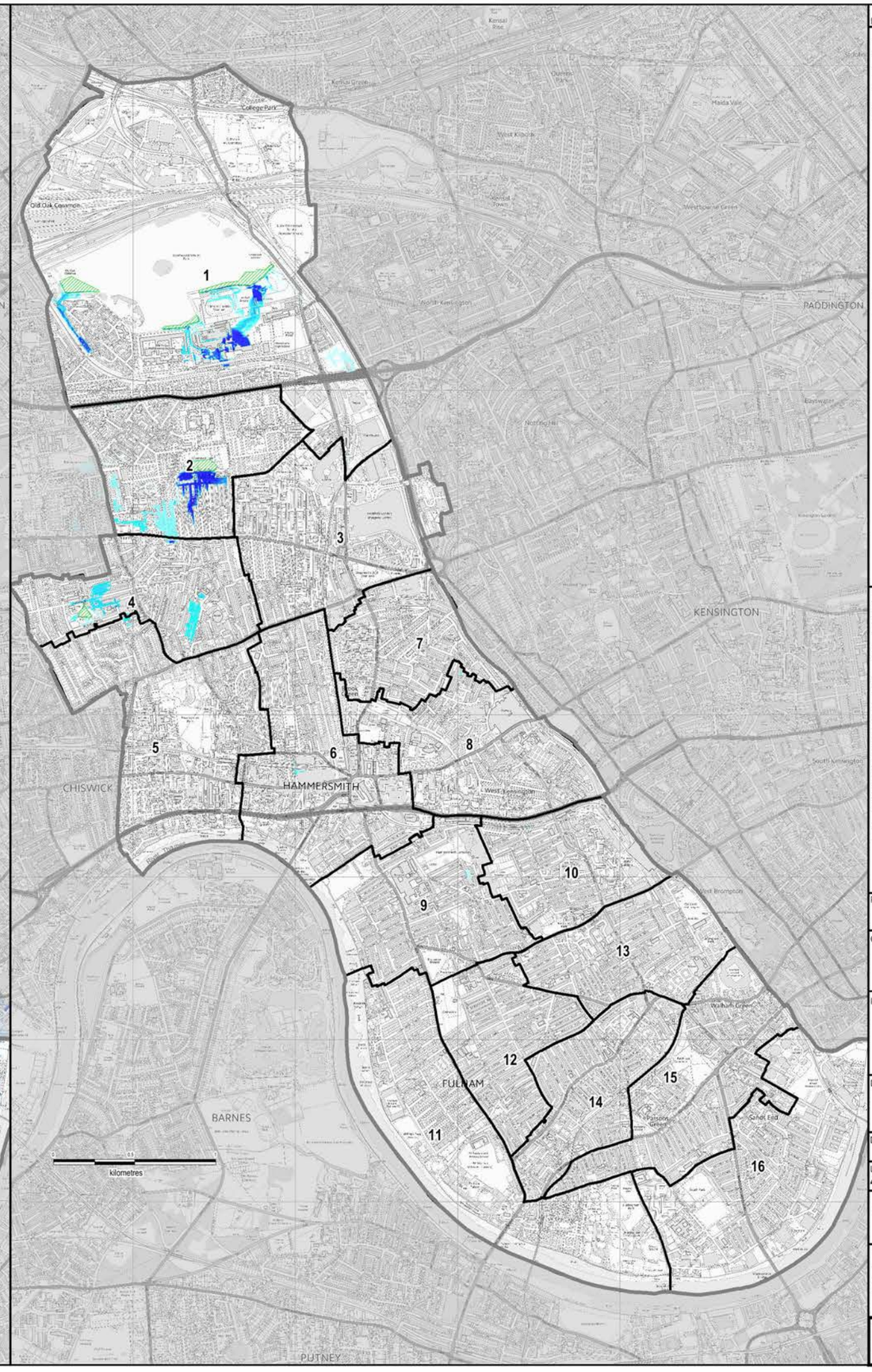
The flood storage bunds have been modelled to effectively retain surface water runoff for all of the modelled return period events. The greatest flood depth reduction can be seen for the 1% and 0.5% AEP events, during which the greatest volumes of surface water are retained.

Wormholt Park: The flood storage area within Wormholt Park has been modelled to allow for the flow of surface water to be diverted to the park and away from the residential area of Dunraven Road and Adelaide Grove to the south. The modelled option is shown to retain approximately 6,600m^3 of surface water during the 5% AEP event. The allowance for flood storage within the park reduces the modelled flood depths at the properties by 15mm to up to 25mm for the same rainfall event.

During the 10% AEP rainfall event, the flood storage area within Wormholt Park results in reductions of maximum flood depth of 0.01m for the residential area to the south. The effect of the storage area is more evident during the 5%, 1.33% and 1% AEP events, when increasingly significant volumes of water are retained within the park area and the areas to the south area shown to have flood depths reduced by approximately 0.15m.

Wendell Park: The flood storage area within Wendell Park has been modelled to allow for the flow of surface water to be diverted into the park and away from the residential areas of Cobbold Road, Becklow Road and Gayford Road to the east. The flood storage option is modelled to retain 480m^3 of surface water during the 5% AEP event. The effect of this is to reduce the maximum surface water flood depths in the area to the east by approximately 0.02m. In addition, areas to the east, on Westville Road and, Bassein Park Road are shown to have benefited with reduced flood depths. It should be noted that due to the predominant flow paths in this area, there is the potential to provide greater flood





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LEGEND

LBHF Administrative Boundary

Ward Boundary

Surface Water Flood Depth (m)

- < 0.1m
- 0.1 - 0.25m
- 0.25 - 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- > 1.5m

Reduction in maximum flood depth (m)

(Calculated from 'Option Depth minus Baseline Depth')

- -0.1m
- -0.01m
- 0 (No Change)

Flood Storage Areas

Ward Names

1 - College Park and Old Oak
2 - Wormholt and White City
3 - Shepherd's Bush Green
4 - Askew
5 - Ravenscourt Park
6 - Hammersmith Broadway
7 - Addison
8 - Avonmore and Brook Green
9 - Fulham Reach
10 - North End
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NOTES

Hydraulic modelling has been undertaken using linked 2D-1D hydraulic modelling software TUFLOW-ESTRY (ver 2012). Refer to the LBHF Model Build Report (2015) for further information on model limitations. The intended purpose of this drawing is to illustrate flood depth in areas in excess of 81m2. Due to the coarse nature of the data the results should not be used to examine flooding at property level.

Purpose of Issue: FINAL

Client: h&f hammersmith & fulham

Project Title: LONDON BOROUGH OF HAMMERSMITH AND FULHAM UPDATED SURFACE WATER MANAGEMENT PLAN

Drawing Title: OPTION 4: FLOOD STORAGE FLOOD DEPTH AND AREAS OF BETTERMENT (5% AEP)

Drawn	Checked	Approved	Date
SL	MI	MT	08/04/2015

URS Internal Project No.: 47065080

Scale at A3: 1:95,000

URS Infrastructure & Environment UK Limited
6 - 8 Greencoat Place
London
SW1P 1PL
Telephone +44 (0)207 7985000

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storage through additional modification of the road network to channel flow more effectively.

The flood storage area within Wendell Park has the most notable effect for larger return period events, where larger volumes of flows are directed in to the storage area and the areas shown to benefit are also more extensive.

Property Counts

The options modelling indicates, that for the installation of these flood storage areas Borough, has the following effect on flooded property counts:

- 4173 residential properties and 541 non-residential properties flood to a depth of >0.1m for the 5% AEP event across the Borough. This is a reduction of 397 properties across the borough in comparison to the baseline scenario.
- 203 residential property and 27 non-residential properties flood to a depth of >0.5m for the 5% AEP event, across the Borough. This is a reduction of 40 properties across the borough in comparison to the baseline scenario.

Additional Benefits

In addition to the surface water storage benefits described above, flood storage areas can be developed to provide a range of additional social and environmental benefits. Detention basins can be developed so that there is minimal compromise with the use of the land, through the temporary storage off flood waters. Alternatively, systems can be developed, such as bioretention areas, which can be planted to provide increased biodiversity, aesthetics, water and air quality improvements. The social and educational value of these areas can be increased through the provision of board walks to enable access and interaction with the local environment.

Costs

Indicative costs for the construction of these flood storage areas have been undertaken utilising cost estimates provided in the Spons: Civil Engineering and Highways (2013).

Wormwood Scrubs and Old Oak Common: The construction of the three flood storage bunds would cost in the region of £51k - £100k

Wormholt Park: the construction of this flood storage area would be in the region of £101k - £250k.

Wendell Park: The construction of the flood storage area and reduction of road levels for this option would be in the region of £251k - £500k. N.B. a large portion of this cost estimate has been found to be due to the estimated cost of profiling of the road.

Maintenance requirements for detention basins and flood storage bunds would typically include annual grass cutting. Following a flooding event, more intensive maintenance would be required to remove pollutants that would contaminate the area. It is estimated that the present value for maintenance, assuming a 10% AEP flooding event occurring, would equate to £101k - £250k / ha of storage area.

Recommendation 13: Consider the potential for development of larger scale flood storage options in Wards 1, 2 and 4.

Option A:	Investigate the feasibility of the development of flood storage in Wormwood Scrubs and Old Oak Common.
Option B:	Investigate the feasibility of the development of flood storage in Wormholt Park with associated re-contouring of road levels to channel surface water flow.

Option C:	Investigate the feasibility of the development of flood storage in Wendell Park with associated re-contouring of road levels to channel surface water flow.
Option D:	Examine the potential for the development of detention basins in open spaces across the Borough. Examination of flow routes and flood zones to potentially develop multifunctional flood storage areas that retain surface water during times of flooding.

Borough Wide Options: Raising Community Awareness (Non-structural measure 5)

A 'quick win' action that should be implemented in the short-term is to increase awareness of flooding within communities at risk, and across the Borough as a whole. This could be achieved through a number of measures including:

- Newsletters (Figure 4.3-5);
- Drop-in surgeries;
- Promotion on LBHF's website; and/or
- Community Flood Plan.

The aim of this action is to raise awareness of the risks and consequences of surface water flooding amongst local communities and, through this, encourage residents to take up measures to combat flooding, such as installation of water butts to capture roof runoff and consideration to the extent and materials used when replacing permeable areas with hard standing areas within their property e.g. through the installation of permeable driveways and patios.

Figure 4.3-5 Example Newsletter (URS / Scott Wilson, 2011)

Recommendation 14: Consider and implement options for raising community awareness including letter drop, information portal and/or preparation of a Community Flood Plan.	
Option A	Undertake a letter drop to highlight the improvement works that have been implemented as well as works that are planned for the future.
Option B	Hold a public meeting following the letter drop where residents can highlight any issues. This could include a talk from the key partner organisations – Environment Agency, Thames Water Utilities Ltd and LBHF – on the work that is being undertaken and who is responsible. Such a meeting should also outline how residents can help themselves and highlight their responsibility for maintaining private drainage, soakaways, driveway drainage etc.
Option C	Develop an 'Information Portal' via the LBHF website, for local flood risk information including links to the relevant Environment Agency web pages that provide advice on measures that can be taken by residents to mitigate surface water flooding to / around their

Borough Wide Options: Raising Community Awareness (Non-structural measure 5)	
	property. The relevant information and links could include: • A list of appropriate property-level flood risk resilience measures that could be installed in a property; • A list of 'approved' suppliers for providing local services, such as repaving of driveways; • A link to websites / information sources providing further information; • An update on work being undertaken in the Borough by the Council and/or other Stakeholders to address surface water flood risk; and, • A calendar showing when gullies are to be cleaned in given areas, to encourage residents to ensure that cars are not parked over gullies / access is not blocked during these times.
Option D	Consider preparing a Community Flood Plan for those communities identified to be at high risk.

Borough Wide Option: On-going Improvements to Maintenance of Drainage Network (Non-structural measure 6)

The management and maintenance of urban drainage network in the LBHF is the responsibility of a number of organisations:

- LBHF – highway drainage including gully pots, non-main river channel maintenance and surface water;
- Thames Water Utilities Ltd - main sewers and lateral sewers;
- TfL – highway drainage along the 'Red Routes'; and
- Network Rail - railway drainage.

Effective cleansing of gully pots is fundamental to the drainage across the Borough and LBHF operates a regular maintenance regime for gully cleansing. Gully pots are fundamental to integrated urban drainage in that during intense precipitation events, surface water runoff is routed off roadways and other hard-standing into gully pots and then into the public sewer system. In essence, gully pots are a critical link in the performance of the overall drainage network.

Recommendation 15: Consider opportunities for on-going improvements to the maintenance of the drainage network.	
Option A	Gullies that are known to flood could be painted yellow to encourage residents to check if they are blocked and to avoid parking directly over them thereby preventing access for gully clearing team.
Option B	Encourage gully cleansing contractors to use powers to enforce movement of parked cars to ensure all gullies are regularly cleared.
Option C	Coordinate timing of gully cleansing rounds to ensure that they do not coincide with school opening and closing times and other peak times that would prevent gaining access to gullies.
Option D	Focus attention on the maintenance of gully pots in the identified flooding hotspots which

Borough Wide Option: On-going Improvements to Maintenance of Drainage Network (Non-structural measure 6)	
	are considered to be high risk and on those areas identified as being at risk from blocked gullies
Option E	As LLFA, the Council must record and investigate incidents of flooding. It is recommended that the source of flooding be recorded, e.g. gully surcharging, to inform maintenance priorities.

Borough Wide Options: Planning and development Policies (Non-structural measure 7)

A number of options and policies have been identified for the study area that LBHF and relevant stakeholders may consider adopting as part of their responsibility as LLFA for local flood risk management. The majority of the following options are common across the Borough; however the way in which they are implemented may vary.

As the LBHF is at the downstream end of the Counters Creek catchment, measures should be taken to ensure that boroughs upstream, are aware of their impact on downstream flooding and actively utilise SUDS measures to alleviate the downstream flood risk.

Sustainable Drainage Systems (SuDS)

A number of policies have already been implemented within the LBHF to ensure that new development incorporates Sustainable Drainage Systems (SuDS) wherever possible. It is recommended that these are reviewed and updated where necessary in the light of the Infiltration SuDS Suitability Map shown in Appendix A (Figure A-4). A summary of the type of SuDS that could be utilised is provided below.

SuDS techniques can be used to reduce the rate and volume and improve the water quality of surface water discharges from sites to the receiving environment (i.e. natural watercourse or public sewer etc). Various SuDS techniques are available and operate on two main principles; attenuation and infiltration. All systems generally fall into one of these two categories, or a combination of the two.

Infiltration SuDS

This type of SuDS relies on discharges to ground, where suitable ground conditions exist or are appropriate. Therefore, infiltration SuDS are reliant on the local ground conditions (i.e. permeability of soils and geology, the groundwater table depth and the importance of underlying aquifers as a potable resource) for their successful operation.

Development pressures and maximisation of the developable area may reduce the area available for infiltration systems. This can be overcome through the use of a combined approach with both attenuation and infiltration techniques e.g. attenuation storage may be provided in the sub-base of a permeable surface, within the chamber of a soakaway or as a pond/water feature.

Permeable surfaces are designed to intercept rainfall and allow water to drain through to a sub-base. The use of a permeable sub-base can be used to temporarily store infiltrated run-off underneath the surface and allows the water to percolate into the underlying soils. Alternatively, stored water within the sub-base may be collected at a low point and discharged from the site at an agreed rate.

Types of permeable surfaces include:

- Grass/landscaped areas
- Gravel

Borough Wide Options: Planning and development Policies (Non-structural measure 7)

- Solid Paving with Void Spaces
- Permeable Pavements

Where permeable surfaces are not a practical option more defined infiltration systems are available. In order to infiltrate the generated run-off to ground, a storage system is provided that allows the infiltration of the stored water into the surrounding ground through both the sides and base of the storage. These systems are constructed below ground and therefore may be advantageous with regards to the developable area of the site. Consideration needs to be given to construction methods, maintenance access and depth to the water table. The provision of large volumes of infiltration/sub-surface storage has potential cost implications. In addition, these systems should not be built within 5m of buildings, beneath roads or in soil that may dissolve or erode.

Various methods for providing infiltration below the ground include:

- Geocellular Systems
- Filter Drain
- Soakaway (Chamber)
- Soakaway (Trench)
- Soakaway (Granular Soakaway)

The infiltration SuDS suitability assessment shown in Appendix A (Figure A-4) is based on minimum permeability data obtained from the BGS. There also exist maximum permeability data, however, only the minimum permeability is used, as this is understood to be more representative of the bulk permeability.

Three permeability zones have been identified:

1. **Infiltration SuDS potentially suitable:** Minimum permeability is high or very high for bedrock (and superficial deposits if they exist).
2. **Infiltration SuDS potentially unsuitable:** Minimum permeability is low or very low for bedrock (and superficial deposits if they exist).
3. **Infiltration SuDS suitability uncertain:** Minimum permeability is low or very low for bedrock and high or very high for superficial deposits OR minimum permeability is low or very low for superficial deposits and high or very high for bedrock.

Figure A-4 shows that much of the central section of LBHF is potentially unsuitable for infiltration SuDS; this is where the superficial geology is the impermeable Langley Silt Member (Figure A-5). The suitability of infiltration SuDS in the southern and northern parts of the Borough is uncertain. The uncertainty is associated with the ability of the River Terrace Deposits to the south, and London Clay to the north to store and transmit groundwater without causing flooding and drainage issues. It is noted that this is a high level assessment and only forms an approximate guide to infiltration SuDS suitability; a site investigation is required in all cases to confirm local conditions.

Attenuation SuDS

If ground conditions are not suitable for infiltration techniques then management of surface water runoff prior to discharge should be undertaken using attenuation techniques. This technique attenuates discharge from a site to reduce flood risk both within and to the surrounding area. It is important to assess the volume of water required to be stored prior to discharge to ensure adequate provision is

Borough Wide Options: Planning and development Policies (Non-structural measure 7)

made for storage. The amount of storage required should be calculated prior to detailed design of the development to ensure that surface water flooding issues are not created within the site.

The rate of discharge from the site should be agreed with the LBHF, the Environment Agency and Thames Water Utilities Ltd. If surface water cannot be discharged to a local watercourse then liaison with the Sewer Undertaker should be undertaken to agree rates of discharge and the adoption of the SuDS system.

Large volumes of water may be required to be stored on site. Storage areas may be constructed above or below ground. Depending on the attenuation/storage systems implemented, appropriate maintenance procedures should be implemented to ensure continued performance of the system. On-site storage measures include basins, ponds, and other engineered forms consisting of underground storage.

Basins are areas that have been contoured (or alternatively embanked) to allow for the temporary storage of run-off from a developed site. Basins are designed to drain free of water and remain waterless in dry weather. These may form areas of public open space or recreational areas. Basins also provide areas for treatment of water by settlement of solids in ponded water and the absorption of pollutants by aquatic vegetation or biological activity. The construction of basins uses relatively simple techniques. Local varieties of vegetation should be used wherever possible and should be fully established before the basins are used. Access to the basin should be provided so that inspection and maintenance is not restricted. This may include inspections, regular cutting of grass, annual clearance of aquatic vegetation and silt removal as required.

Ponds are designed to hold the additional surface water run-off generated by the site during rainfall events. The ponds are designed to control discharge rates by storing the collected run-off and releasing it slowly once the risk of flooding has passed. Ponds can provide wildlife habitats, water features to enhance the urban landscape and, where water quality and flooding risks are acceptable, they can be used for recreation. It may be possible to integrate ponds and wetlands into public areas to create new community ponds. Ponds and wetlands trap silt that may need to be removed periodically. Ideally, the contaminants should be removed at source to prevent silt from reaching the pond or wetland in the first place. In situations where this is not possible, consideration should be given to a small detention basin placed at the inlet to the pond in order to trap and subsequently remove the silt. Depending on the setting of a pond, health and safety issues may be important issues that need to be taken into consideration. The design of the pond can help to minimise any health and safety issues (i.e. shallower margins to the pond reduce the danger of falling in, fenced margins).

Various types of ponds are available for utilising as SuDS measures. These include:

- Balancing/Attenuating Ponds
- Flood Storage Reservoirs
- Lagoons
- Retention Ponds
- Wetlands

Site constraints and limitations such as developable area, economic viability and contamination may require engineered solutions to be implemented. These methods predominantly require the provision of storage beneath the ground surface, which may be advantageous with regards to the developable area

Borough Wide Options: Planning and development Policies (Non-structural measure 7)

of the site but should be used only if methods discussed above cannot be used. When implementing such approaches, consideration needs to be given to construction methods, maintenance access and to any development that takes place over the storage facility. The provision of large volumes of storage underground also has potential cost implications.

Methods for providing alternative attenuation include:

- Deep Shafts
- Geocellular Systems
- Oversized Pipes
- Rainwater Harvesting
- Tanks
- Green and Brown Biodiverse Roofs

In some situations it may be preferable to combine infiltration and attenuation systems to maximise the management of surface water runoff, developable area and green open space.

Recommendation 16: Ensure Development Control Policy incorporates surface water flood risk conditions and the latest available surface water flooding information including runoff rates, SuDS etc.

Borough Wide Options: Water Conservation (Non-structural measure 8)

Water conservation is a key option for reducing peak discharges and in turn downstream flood risk. This can be applied using a number of options including planning led encouragement of the use of rainfall in rainwater harvesting systems and property level use of water butts. Both are described in more detail below.

Rainwater Harvesting

The potential for the storage and re-use of rainwater should be jointly led by Thames Water Utilities Ltd. and the council. Promotion of the benefits of such schemes could be rolled out across multiple Boroughs to reduce costs. The principle of rainwater harvesting in both domestic and commercial property is the same. Rainwater from roof areas is passed through a filter and stored within large underground tanks. When water is required, it is delivered from the storage tank to toilets, washing machines and garden taps for use. If the tank becomes low on stored water, demand is topped up from the mains supply. Any excess water can be discharged via an overflow to a soakaway or local drainage network.

Rainwater harvesting systems could be retrofitted to local schools within the Borough. A case study for Southampton University Student Services Building is described below, with an example layout of a system illustrated in Figure 4.3-[xiv]:

- Roof Area: 1000m^2

[xiv] Source: Rainwaterharvesting Systems UK

Borough Wide Options: Water Conservation (Non-structural measure 8)

- Underground storage tank: 15,000 litres
- Building occupancy: 150 people
- Planned usage: 21 WCs and 3 urinals
- Expected annual rainwater collection: 410,000 litres
- Capital cost: £4,325
- Expected pay back time 5.3 years (based on Southern Water 2006 tariff)

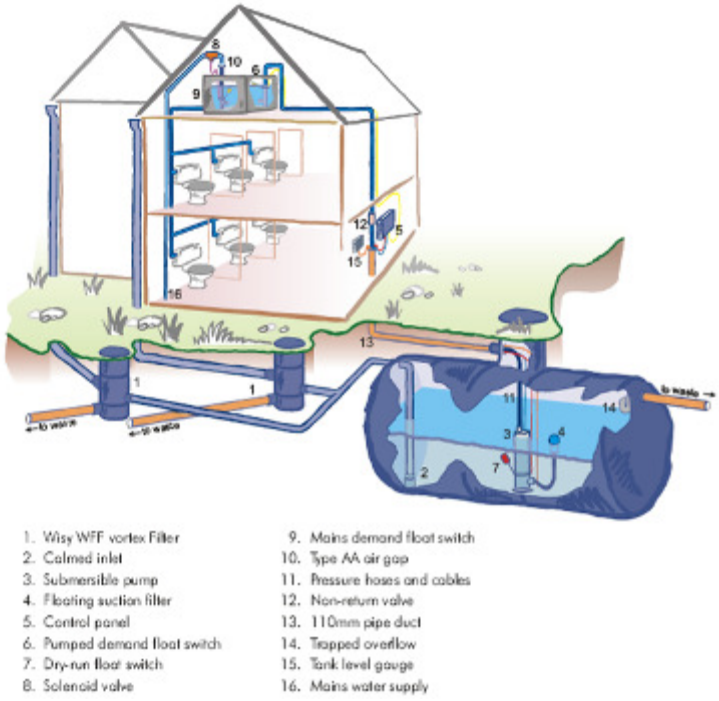

Figure 4.3-6 Example Rainwater Harvesting System in a Commercial Property

Recommendation 17: Consider opportunities to promote rainwater harvesting in both new and existing development throughout the LBHF.	
Option A	The Council along with Thames Water Utilities Ltd. could consider providing an incentive scheme for the use of rainwater harvesting systems across the Borough.
Option B	The Council could consider retrofitting rainwater harvesting systems on Council owned properties, such as schools, for example, which offer educational opportunities as well as local surface water flood mitigation.

Water Butts

One possible measure to reduce peak discharges and downstream flood risk is the use of water butts on all new development within the LBHF. Where higher surface water flooding risk has been identified, retrofitting of water butts to existing properties could also offer benefits. Given the constraints associated with infiltration in much of the Borough, the wholesale implementation of water butts can significantly reduce peak discharges.

Borough Wide Options: Water Conservation (Non-structural measure 8)	
Water butts often have limited storage capacity given that when a catchment is in flood, water butts are often full, however it is still considered that they have a role to play in the sustainable use of water and there is potential to provide overflow devices to soakaways (where geology permits) or landscaped areas to ensure that there is always a volume of storage available. Whether to construct formal spill pipes to soakaways, or to allow simple overspill to the adjacent ground are detailed decisions that will need to be based on a site-by-site basis; this will have only minor significance on the proposals with respect to the surface water drainage.	

Figure 4.3-7 Example of a 100L Water Butt Retrofitted to Existing Development

Recommendation 18: Consider opportunities to promote use of water butts in both new and existing development throughout the LBHF.	
Option D	Consider installation of water butts for all new development. This ties in with the SuDS hierarchy and reduces peak discharges to surface water and is likely to have positive impacts to sustainability and water re-use
Option E	Consider retrofitting water butts on all existing development (as shown in Figure 4.3-7). This provides supplementary benefits beyond regeneration and redevelopment sites (volumetric reduction with opportunity for complimentary water quality improvements). However there are currently no available incentives to encourage homeowners to install water butts.
Option F	It is recommended that the Council promote the use of water butts across the Borough and provide information (either directly or through links to external websites) on potential costs, installation and benefits.

Borough Wide Options: Improving Resilience to Flooding (non-structural measure 9)
Property Resilient Measures (Increasing Property or Gate Thresholds)
One method to reduce the risk of surface water flooding to properties is raising property thresholds. Raising the threshold of entrances to property land, i.e. where there are currently gates adjacent to paved walls (Figure 4.3-8) may offer flood resilience benefits, especially where the property contains a basement. Property level thresholds could also be increased where possible to improve resilience to surface water flooding, and especially where roads are predicted to flood and the properties contain no front gardens (Figure 4.3-8). Thresholds as shown in Figure 4.3-8 are a useful and an accepted method of defending property

Borough Wide Options: Improving Resilience to Flooding (non-structural measure 9)
Property Resilient Measures (Increasing Property or Gate Thresholds)
against flooding, although this can conflict with possible accessibility issues within Part M, Section 6 of the Building Regulations 2004 and the requirements of the Disability Discrimination Act 1996 (DDA). Until such time as national guidance or best practice is available LBHF will, when required, work with developers and residents to realise suitable, sensible and cost effective solutions which allow access and deliver mitigation against possible flooding.   **Figure 4.3-8 Example of Raised Property Thresholds** Similarly, opportunities should be sought to improve the flood resilience of properties below ground level, in order to reduce the risk of flooding resulting from overland flow or backflow from sewers. Measures to improve the flood resilience of below ground properties could include the provision of active drainage devices, such as a pumped solution, in accordance with Policy HO11 of the draft Local Plan 2015[xv].
Recommendation 19: Consider opportunities to promote awareness of property level thresholds throughout the LBHF, particularly in areas of higher flood risk

Option A	It is recommended that the Council work with residents to develop solutions that maintain access and deliver mitigation, particularly in areas where roads / properties are known / identified to be susceptible to surface water flooding.

Community Flood Plans
Completing a Community Flood Plan will help communities decide what practical actions to take before

[xv] Hammersmith and Fulham Council. January 2015. 'Draft Local Plan - Regulation 18 Consultation'. Paragraph 7.59, Pg. 110.

Borough Wide Options: Improving Resilience to Flooding (non-structural measure 9)
Property Resilient Measures (Increasing Property or Gate Thresholds)
and during a flood, which may help reduce the damage flooding could cause. The flood planning process makes use of local knowledge and experience to produce a plan that caters for (a) preparing for a flood, (b) during a flood, and (c) after a flood, and should aim to complement the authorities' emergency plans and to provide essential information to help manage a flood event. Working together as a community or group has multiple benefits, including: • Sharing information on what to expect and what to do before, during and after a flood incident; • Identify and clarify the responsibilities of all those involved (this avoids duplication, saving time and money); • Clarifying the responsibilities of all those involved; • Improving communication throughout the community and with the organisations involved before, during and after a flood; • Help share local knowledge and that of people who have been flooded with professional organisations and ensure people's concerns are heard; • Increasing preparedness to reduce the damage and distress of a flood; • Being involved in flood planning will enable a community or group to take control and help during a flood, when other organisations could be overstretched or unable to reach them; and, • Increasing community resilience. Further information regarding Community Flood Plans (including a Community Flood Plan Pack) is available on the Environment Agency's website: http://www.environment-agency.gov.uk/homeandleisure/floods/38329.aspx.
Recommendation 20: Identify areas where Community Flood Plans may be effective and consider opportunities to develop these, in conjunction with the local community.

4.4 Recommendations For Next Steps

4.4.1 Taking into account the nature of the surface water flooding in the LBHF, the options identified through the Phase 3 – Options Assessment it is considered that the options identified in

4.4.2 Table 4-4 should be prioritised in the short to medium-term:

Table 4-4 Recommendations for Next Steps

Borough-Wide	**Recommendation 10:**	Consider and implement options for installation of tree planters across the Borough and the utilisation of space around existing trees.
	Recommendation 11:	Consider and implement installation of green roofs on a site by site basis for suitable council buildings, taking advantage of current feasibility investigations.
	Recommendation 12:	Consider and implement installation of permeable paving across council owned open spaces through the review of the site maintenance regime and refurbishment programmes.
	Recommendation 13:	Consider and implement the potential for development of larger scale flood storage options across Wards 1, 2 and 4.
	Recommendation 14:	Consider and implement options for raising community awareness including letter drop, information portal and/or preparation of a Community Flood Plan.
	Recommendation 15:	Consider and implement opportunities for ongoing improvements to the maintenance of the drainage network.
	Recommendation 16:	Ensure Development Control Policy incorporates surface water flood risk conditions and the latest available surface water flooding information including runoff rates, SuDS etc.
	Recommendation 17:	Consider and implement opportunities to promote rainwater harvesting in both new and existing development throughout the LBHF.
	Recommendation 18:	Consider and implement opportunities to promote use of water butts in both new and existing development throughout the LBHF.
	Recommendation 19:	Consider and implement opportunities to promote awareness of property level thresholds throughout the LBHF, particularly in areas of higher flood risk.
	Recommendation 20:	Consider and implement opportunities to promote awareness of property level thresholds throughout the LBHF, particularly in areas of higher flood risk.

5 PHASE 4 : IMPLEMENTATION AND REVIEW

5.1 Action Plan

5.1.1 The purpose of Phase 4 of the SWMP is to clearly identify actions and responsibilities for the ongoing management of surface water flood risk within the LBHF that have been identified throughout the work undertaken in Phases 1 to 3. These build on the recommendations identified throughout the SWMP and options developed through Phase 3.

5.1.2 An Action Plan has been created for the LBHF and is located within Appendix E. The Action Plan is a simple summary spreadsheet that has been formulated by reviewing the previous phases of the SWMP in order to create a useful set of actions relating to the management and investigation of surface water flooding going forward.

5.1.3 LBHF are also required to complete a Local Flood Risk Management Strategy (LFRMS) under the FWMA 2010. LBHF should aim to utilise this Action Plan to inform the preliminary stages of the LFRMS document and to support and inform future studies.

5.1.4 The Action Plan identifies:

- Actions required to meet the requirements for LBHF as LLFA under the FWMA 2010 and Flood Risk Regulations 2009;
- Future studies and consultations for investigation and confirming the level of flood risk within the Borough;
- The partners or stakeholders responsible for implementing and supporting the actions;
- An indication of when the actions should be undertaken, reviewed and updated (these should be confirmed by the LBHF upon adoption of the draft Action Plan);
- An indication of the priority of the actions – high, medium or low to aid the LBHF in prioritising the actions; and
- Linkages between actions.

Recommendation 21: Develop, update and maintain the draft Action Plan to meet the LBHF's local flood risk management priorities.

5.2 Summary of Key Actions

5.2.1 The key (high priority) actions for the LBHF over the short- to medium-term, on the whole, relate to requirements under the FWMA 2010 and Flood Risk Regulations 2009, and general actions and investigations that apply to the wider Borough and consultation with professional and political stakeholders and the public.

5.2.2 Proposed actions have been classified into the following timeframes:

- Short term - Actions to be undertaken within the next year;
- Medium term - Actions to be undertaken within the next year to five years; and
- Long term - Actions to be undertaken beyond the next five years.

5.2.3 A number of recommendations have been identified throughout the report and have been incorporated within the Action Plan shown in Appendix E. All actions included within Table 5-1 have been identified as 'High Priority' actions. The reader is referred to the Action Plan in Appendix E for all actions identified for the LBHF.

5.2.4 The Environment Agency allocate FCERM GiA capital grants and Thames Regional Flood and Coastal Committee (TRFCC) local levy to flood defence projects, subject to TRFCC approval. The amount of government funding allocated by the EA to a project is based upon the likely public benefit that will be provided. Benefits include reducing flood risk to households, businesses and infrastructure and creating habitat for wildlife. Regional Flood and Coastal Committees raise local levy from local authorities to fund local priorities.

Recommendation 22: Identify local flood risk management funding opportunities through internal, external, existing and future funding initiatives and mechanisms.

5.2.5 A summary of the key actions are:

- **FWMA 2010 / Flood Risk Regulations 2009 Actions** - A number of the key actions for LBHF relate to duties and responsibilities under the FWMA 2010 and the Flood Risk Regulations 2009 outlined in Section 1.7. It is likely that these actions may require consideration of internal Borough functions, roles of specific personnel, and adopting new systems of data collection and asset management. For clarity it is noted that the FWMA places immediate or in some cases imminent new responsibilities on LLFAs.
- **Financial / Resourcing Actions** - To deliver the requirements of the FWMA 2010 and, to a lesser extent, the Flood Risk Regulations 2009, alongside local flood risk management actions as identified in this SWMP, the LBHF is likely to require additional resources and funding over the long-term.
- **Communication / Partnerships Actions** - As our understanding about surface water flood risk improves and more information is made available, it becomes increasingly important to be able to communicate the risk effectively both within LBHF and to other stakeholders and members of the public. To this end a number of actions relate to the future communication of flood risk and the LBHF may wish to consider the implementation of a Communication Plan to deliver this action. LBHF should continue to forge partnerships with the neighbouring boroughs of Ealing and RBKC to continue the management of surface water across this area in a joined-up manner. Collaboration with neighbouring London Boroughs is also likely to aid each local authority in meeting the requirements of the Flood Risk Regulations 2009 and taking on new roles and responsibilities under the FWMA 2010.
- **Policy Actions** - Actions that will need to be delivered through policy include policies or strategies for influencing the use of rainwater harvesting techniques and the use of SuDS. These may be delivered across the Borough or for specific areas within the Borough.
- **Investigation / Feasibility / Design Actions** - Further analysis of options will need to be undertaken to deliver actions. This includes the Borough wide actions, as well as for specified areas. Within the LBHF, these are predominantly either capital works in the form of SuDS and creation of flood storage areas, or further investigation through more detailed modelling and initial surveys or, where appropriate, feasibility studies.
- **Flooding Mitigation Actions** - There are some flooding mitigation actions which can be progressed immediately without any further investigation to assist in the delivery of

flood risk management and mitigation across the Borough, or within specific Wards. It is recommended that improved and targeted maintenance of the drainage network is one of the key actions over the next 1-2 years, whilst longer-term flood mitigation options and schemes are investigated and designed.

Table 5-1 High Priority Actions for the LBHF SWMP

	Recommendation	Action Type	Timeframe	Responsibility[xvi]		Action Plan ID
				Lead	Other	
1	Continue to work towards fulfilling the requirements under the Flood and Water Management Act 2010 and Flood Risk Regulation 2009	FWMA 2010 / FRR 2009	Short	LBHF	All	LBHF1 – LBHF 7
2	Establish a Flood Risk Management Group for the LBHF (as LLFA) to take forward FWMA and SWMP actions and Local Flood Risk Management.	FWMA 2010 / FRR 2009	Short	LBHF	All	LBHF4
3	Ensure required skills and capacity are in place within (or between) LLFA(s) to deliver FWMA and Local Flood Risk Management requirements.	FWMA 2010 / FRR 2009	Medium	LBHF	EA	LBHF15
4	Actively engage with members of the public regarding local flood risk management and formulation of the LFRM Strategy.	FWMA 2010 / FRR 2009	Short	LBHF	All	LBHF8
5	Implement a standardised Flood Incident Log to record and investigate future flooding incidents.	FWMA 2010 / FRR 2009	Short	LBHF	-	LBHF3
6	Work with the Thames Water Utilities Ltd. to identify opportunities for the integrated management of surface water and sewer flooding across the Borough.	Investigation / Feasibility / Design	Medium	LBHF	TWUL	LBHF12
7	Work with the Environment Agency to record and investigate groundwater flooding incidents and mechanisms.	Investigation / Feasibility / Design	Medium	LBHF	EA	LBHF9
8	Actively engage with professional stakeholders to communicate findings of SWMP and local flood risk management.	Communication / Partnerships	Short	LBHF	-	LBHF19
9	Design and gain buy-in to a Communication and Engagement Plan to identify how to effectively communicate and raise awareness of local flood risk to different audiences.	Communication / Partnerships	Short	LBHF	EA, TWUL, GLA, Com	LBHF17
10	Consider and implement options for installation of tree planters across the Borough and the utilisation of space around existing trees.	Flooding Mitigation Action	Short	LBHF	TfL, Comm	LBHF33

[xvi] Abbreviations for Organisations: LBHF = London Borough of Hammersmith & Fulham; RBKC = Royal Borough of Kensington & Chelsea; LBE = London Borough of Ealing; EA = Environment Agency; TWUL = Thames Water Utilities Limited; GLA = Greater London Authority; NR = Network Rail; TfL = Transport for London; LU = London Underground; LC = London Councils; Com = Communities / General Public; All = All third parties involved in local flood risk management

	Recommendation	Action Type	Timeframe	Responsibility[xvi]		Action Plan ID
				Lead	Other	
11	Consider installation of green roofs on a site by site basis for suitable council buildings, taking advantage of current feasibility investigations.	Flooding Mitigation Action	Short	LBHF	-	LBHF32
12	Consider installation of permeable paving across council owned open spaces through the review of the site maintenance regime and refurbishment. **programmes**	Flooding Mitigation Action	Short	LBHF	TfL, Comm	LBHF36
13	Consider the potential for development of larger scale flood storage options across Wards 1, 2 and 4.	Flooding Mitigation Action	Short	LBHF	-	LBHF35
14	Consider and implement options for raising community awareness including letter drop, information portal and/or preparation of a Community Flood Plan.	Communication / Partnerships	Medium	LBHF	Com	LBHF24
15	Consider opportunities for on-going improvements to the maintenance of the drainage network**.**	Flooding Mitigation Action	Short	LBHF	TWUL, TfL	LBHF31
16	Ensure Development Control Policy incorporates surface water flood risk conditions and the latest available surface water flooding information including runoff rates, SuDS etc.	Policy Action	Medium	LBHF	EA	LBHF38
17	Consider opportunities to promote rainwater harvesting in both new and existing development throughout the LBHF.	Policy Action	Medium	LBHF	EA	LBHF46
18	Consider opportunities to promote use of water butts in both new and existing development throughout the LBHF.	Flooding Mitigation Action	Medium	LBHF	EA	LBHF50
19	Consider opportunities to promote awareness of property level thresholds throughout the LBHF, particularly in areas of higher flood risk.	Communication / Partnerships	Medium	LBHF	Com	LBHF53
20	Identify areas where Community Flood Plans may be effective and consider opportunities to develop these, in conjunction with the local community.	Communication / Partnerships	Medium	LBHF	Com	LBHF28
21	Develop, update and maintain the draft Action Plan to meet the LBHF's local flood risk management priorities.	FWMA 2010 / FRR 2009	Short	LBHF	-	LBHF14
22	Identify local flood risk management funding opportunities through internal, external, existing and future funding initiatives and mechanisms.	Financial / Resourcing	Short	LBHF	EA	LBHF16

5.3 Review Timeframe and Responsibilities

5.3.1 The Action Plan identifies the relevant internal departments and external partnerships that should be consulted and asked to participate when addressing an action, though these should be checked and confirmed by the LBHF as the first stage in taking forward their Action Plan recommendations. After an action has been addressed, it is recommended that the responsible department (responsible for completing the action) review the Action Plan and update it to reflect any issues (communication or stakeholder participation) which arose during the completion of an action and whether or not additional actions are required.

5.3.2 It is recommended that the Action Plan is reviewed and updated on a yearly basis to reflect any works undertaken by the Council and other stakeholders.

5.4 Ongoing Monitoring

5.4.1 The partnership arrangements established as part of the SWMP process (e.g., RBKC, Environment Agency, and Thames Water Utilities Ltd. working in collaboration) should continue beyond the completion of the SWMP in order to discuss the implementation of the proposed actions, review opportunities for operational efficiency and to review any legislative changes.

5.4.2 The SWMP draft Action Plan should be reviewed and updated once annually as a minimum, but there may be circumstances which might trigger a review and/or an update of the Action Plan in the interim, for example:

- Occurrence of a surface water flood event;
- Additional data or modelling becoming available, which may alter the understanding of risk within the study area;
- If the outcome of an investment decision by partners is different to the preferred option, which may require a revision to the action plan, and;
- Additional (major) development or other changes in the catchment which may affect the surface water flood risk.

5.5 Updating SWMP Reports and Figures

5.5.1 In recognition that the SWMP will be updated in the future, the report has been structured in chapters according to the SWMP guidance provided by Defra. By structuring the report in this way, it is possible to undertake further analyses on a particular source of flooding and only have to supersede the relevant chapter, whilst keeping the remaining chapters unaffected.

5.5.2 In keeping with this principle, the following tasks should be undertaken when updating SWMP reports and figures:

- Undertake further analyses as required after SWMP review;
- Document all new technical analyses by rewriting and replacing relevant chapter(s) and appendices;
- Amend and replace relevant SWMP Maps; and,
- Reissue to departments within the LBHF and other stakeholders.

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APPENDIX A – FIGURES

APPENDIX B – OPTIONS ASSESSMENT

A review of options for each of the 15 Wards within the Borough has been completed to inform the development of preferred options scenarios.

Appendix B: *LBHF_SWMP_Options_Assessment_v02.pdf*

APPENDIX C – SPATIAL PLANNER INFORMATION PACK

A Spatial Planning Information Pack has been produced as part of the SWMP and is provided electronically alongside this report.

Appendix C: ***LBHF_SWMP_AppendixC_Spatial_Planner_Info_Pack_v04.pdf***

APPENDIX D – FLOOD RESILIENCE FORUM AND EMERGENCY PLANNER INFORMATION PACK

A Resilience Forum and Emergency Planner Information Pack has been produced as part of the SWMP and is provided electronically alongside this report.

Appendix D: *LBHF_SWMP_AppendixD_Emergency_Planning_v02.pdf*

APPENDIX E – ACTION PLAN

Appendix E: *LBHF_SWMP_AppendixE_Action_Plan_v03.pdf*